Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

SEPTEMBER, 1912.

LIFE WITHOUT MICROBES.

By F. P. MANN.

SEEING that microbes are always found to accompany the different manifestations of life, it was, in fact, supposed that they were even a necessary condition for the existence of human beings and animals of different degrees. Scientific men have hitherto been of the opinion that life without microbes would be impossible, at least, for the higher animals, even though recent researches showed that some insects could live when free from such germs. It was very difficult to throw any light upon this very important point, as what was needed was to be able to raise an animal and allow it to grow under conditions in which no microbes could reach it. M. Michel Cohendy, of the Pasteur Institute of Paris, undertook to solve the problem by raising live chickens in an enclosed space which was quite free from

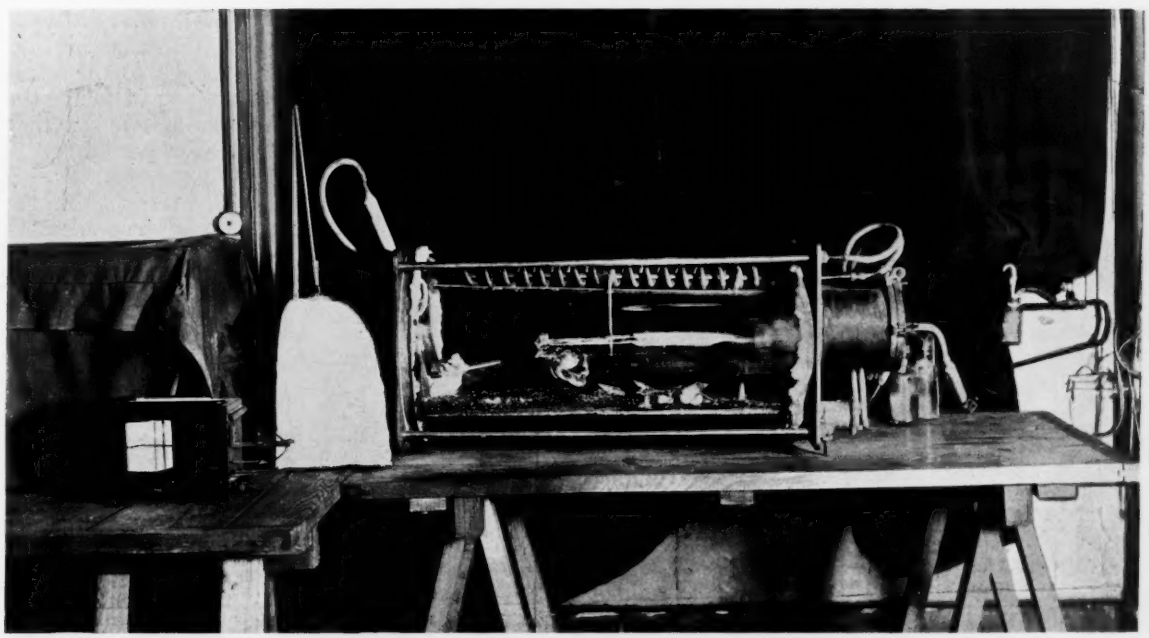

FIGURE 357. M. Michel Cohendy's Apparatus.

microbes. By the use of an ingenious apparatus for hatching the chickens and then raising them for a certain time, he was able to produce animals which did not contain any microbes in their bodies, and they were able to live and appeared to be as healthy as usual. M. Cohendy very kindly furnished us with the present description of his method.

What is needed in the present case is to have a suitable means for raising the chickens, starting with the egg, and then to allow them to grow under good conditions for several weeks, all the while being quite free from microbes. M. Cohendy was obliged to take great care in designing an apparatus which would carry out this purpose, seeing that it is quite easy for it to be contaminated with microbes which are always floating in the air or are contained in the different substances needed within the apparatus. He operated, in the first place, in a special antiseptic room which has the walls and floor well sterilized so as to reduce the number of microbes in the air to a very small amount to begin with. Then he made the apparatus which is represented in Figure 357, and it serves in the first place as an incubator for hatching the eggs and then as a chamber where the chickens are able to live as long as may be desired. The main glass cylinder with an inside sheet metal floor serves for the live chickens, and opening into it on the left hand side is a smaller metal chamber used as the incubator. A felt curtain hangs over the opening between these two chambers. The incubator part is kept covered over with a piece of heat-protecting felt. A round metal door in the incubator end allows of putting in the eggs, and there is a second door in the metal chamber lying at the other end of the cylinder for taking out the live chickens or for putting in grain, sand, and all that is needed here.

The incubator is kept as usual at the right heat for hatching the eggs, by the use of a small outside gas burner placed underneath. But after the chickens are hatched, it is required to use a lower temperature in the glass cylinder in which they are to live, so as to keep it at about the same heat as under ordinary conditions. One precaution to be taken is to keep the heat of the chamber at a somewhat lower point than what prevails in the room, as M. Cohendy found that unless this were done, the vapour within the cylinder will condense and form dew upon the inside, and this runs down and keeps the floor and the sand always wet. This he now avoids by using a worm tube which will be noticed running along the top and inside the cylinder. It has cold water from the main circulating in it, and this water is sterilized along its course before entering the chamber, as an extra precaution. It is also required to supply drinking water to the chickens, and this is done by using a small plate or trough running along under the worm tube. A slight amount of water is always condensed from the chamber upon the cold tube, and this runs down the trough to one end of the chamber where it collects in a small drinking vessel. The grain and sand are well sterilized before putting them into the apparatus so that they are quite free from microbes, as is found by suitable tests in the first place.

Before putting in the eggs, the apparatus as a whole is taken to a sterilizing apparatus, and is put into it and kept at a heat somewhat above the boiling point of water, so as to destroy all the microbes. The two doors of the cylinder are made with rubber joints with an extra protection of cotton which prevents microbes from entering. The air also needs to be kept renewed inside the apparatus while the chickens are living, and this is done by using a tube which runs through the laboratory window to the outer air. An air circulation is kept up in the apparatus, using sterilizers in the path of the tubes, so that the incoming air is quite pure. An ingenious method consists in keeping the air pressure inside the apparatus somewhat higher than what prevails outside, so that when it is required to open one of the doors there is a slight outrush of air from the cylinder so as to drive out any microbes which would tend to enter with the air. It is recognised that eggs when in a healthy state do not contain any microbes in the inside. The outside of the egg is well cleaned and sterilised, then three or four eggs are put into the incubator. This requires the utmost care in order to keep any germ-laden air from entering at the same time, and the author makes use of a rubber cloth-covered box which is quite similar to a photographic plate charging box, with holes for the arms. The inside of the box is carefully sterilized, so that this allows of taking the eggs in the hands and by means of the box they are placed within the incubator. The protecting box will be noticed to the left of the apparatus. During the raising, a set of open bouillon tubes within the cylinder showed whether there were any microbes inside.

M. Cohendy thus succeeded in raising chickens for forty-five days which were found by analysis of the contents of the digestive organs, blood and various parts, to be free from microbes. A longer time could not be given, owing to the size of the chamber which was very difficult to make even of the present proportions. A number of check specimens were raised in the same way but the usual microbes were allowed to enter. The author's specimens seemed nevertheless to be as healthy as the others, and when taken out into the air their bodies became peopled with disease and other microbes in about twenty-four hours; but, as might have been expected, they did not suffer at all from this, and the change over did not appear to affect them, as they grew up to adult size. These experiments seem to show that the preparation of the animal organism for fighting disease microbes is not the result of individual acquisition, but is hereditary, and the conclusion is that life without microbes is possible for the higher animals, without any bad effect on the organism. It can no longer be said that microbes are a necessary condition for living animals.

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ON STELLAR AND NEBULAR DISTANCES.

By PROFESSOR FRANK W. VERY.

Westwood Astrophysical Observatory, Westwood, Massachusetts, U.S.A.

AT the meeting of the British Astronomical Association, Wednesday, November 29th, 1911, my paper—"Are the White Nebulae Galaxies?"* was introduced for discussion by Mr. Lynn. In the remarks which followed, some favourable, others adverse, Dr. Crommelin said that "sensible proper motions did not show any perceptible increase in the direction of the Milky Way," and that this was fatal to the distance which I have assigned to the Galaxy. He also cited Newcomb's distance as being fifty times mine.

It is quite true that there are no evidences of a marked increase of proper motion among the galactic stars; but since, in my view, the galactic velocities are small, because they have been annulled to a great extent by internal collisions among the component parts out of which the central condensation has developed (and this is why there is such a great accumulation of material in this region), it follows that sensible proper motions are not to be anticipated among the galactic stars. A velocity of one astronomical unit ($1{\cdot}5 \times 10^8$ kilometres per annum) would give to a galactic star at six hundred billion kilometres (6×10^{14} kilometres) a proper motion of $\frac{200{,}000 \times 150{,}000{,}000}{600{,}000{,}000{,}000{,}000} = 0''{\cdot}05$ per annum. This gives a preliminary conception of the order of magnitude to be expected.

The size which I assumed, namely, $1{\cdot}2 \times (10)^{15}$ kilometres for "the diameter of the galactic spiral in its more condensed discoidal dimension,"* was not intended to include "a wider encompassing shell of sparsely-distributed stars of approximately spherical shape." The latter, reasoning from the analogy of the extreme outer boundary of a star cluster, compared with its condensed nucleus, may be ten times as distant. This gives an outer boundary at a distance $6 \times (10)^{15}$ kilometres from the centre.† Lord Kelvin gave a number five times as large as this for his star-sphere‡, in which, however, he assumed a uniform distribution of the stars, whereas there is undoubtedly a great central condensation and smaller average distance from the centre. It seems to me probable that the real dimensions lie somewhere between these limits.

The immense number of the stars may suggest distances greater than these, but recognizing the great stellar condensation of clusters and galactic streams, the mere numbers, great as they are, do not constitute an insuperable barrier to the supposition that the galactic distances are of the order named.

If the absence of sensible proper motion in many small galactic stars cannot be taken as a sure proof of their great distance, what shall we say of the large proper motions which have been found for considerable numbers of faint stars? Does it not imply that some, at least, of these faint objects are not as far away as the enormous distances which have sometimes been assigned to them? Professor Eastman, classifying a list of five hundred and fifty stars for proper motion, could find no consistent connection between brightness and apparent speed. Twenty-nine stars of the ninth magnitude had an average proper motion three times as great as the average for an equal number of second magnitude stars. Professor Eastman notes that "assumption, which has developed into a quasi-theory and gained general acceptance, asserts that the largest stars are nearest the solar system. Observation plainly shows this theory is untenable."§

If the star-ratio per successive magnitude were purely a space-ratio, it should continue to increase indefinitely for the smaller magnitudes (given sufficient telescopic power). Existing telescopes may not have quite power enough to fix a limit for the galactic stars. Although there is an apparent falling off in the star-ratio beyond the sixteenth magnitude, there may be some doubt whether the photograph registers these very faint stars correctly.

The case is different for extra-galactic regions. Here there is abundant telescopic power, and it is certain that the curve of the star-ratio per magnitude is not a space-ratio, but more nearly resembles the probability curve for distribution of real variation of brightness. This has been recognized, in a way, for some time.

Miss Clerke says: "Somewhere, if the stellar system be—as we have reason to think it is—of finite dimensions, ... distance becoming at length eliminated as a factor of magnitude, the differences of the faintest stars represent, chiefly or solely, real inequalities in shining. There may possibly, for instance, be no 'mean distance'

* *Astronomische Nachrichten*, No. 4536, Bd. 189, November, 1911. *Op. cit.*, column 450.

† Compare F. W. Very, "Stellar Revolutions within the Galaxy," *Am. Journ. of Sci.*, Ser. 4, Vol. XVI, page 132, Aug. 1903.

‡ *Philosophical Mag.* (6), Vol. II, page 161, 1901; also Vol. III, page 1, 1902.

§ *Bulletin Philosophical Society of Washington*, Vol. XI, page 166.

corresponding to the sixteenth magnitude. The stars of that rank would not then, on the whole, be further off than those of the rank next above them, but would, on the whole, possess only $\frac{1}{2 \cdot 5^{12}}$ of their real light."* Yet, in spite of this quasi-recognition of the fallacy of the position that the star-ratio represents a space-ratio, statistical studies of assumed stellar distribution continue with very little regard for this fact.

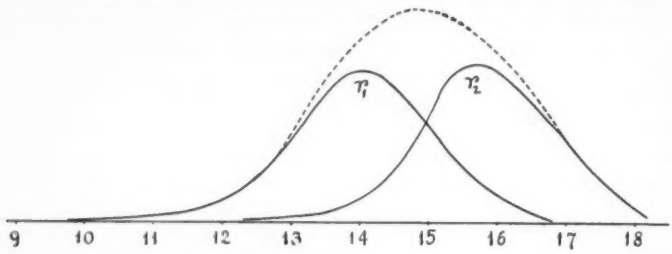

FIGURE 358.

Admitting the extreme condensation of small stars in certain galactic streams, we may possibly reach some approximate estimate of the arrangement and star-density of these streams.

The superposition of distinct galactic rings is strongly suggested by Ritchey's photograph of the Milky Way in Cygnus, near N.G.C. 6960,† where the star density in the right-hand half of the plate suddenly increases to about double that on the left. The following counts are reduced to numbers of stars per square degree:

Left side.		Right side.	
43,600	Mean 35,000	65,200	Mean 78,000
29,500		70,600	
31,300		98,300	

Let us see if these numbers can be represented by a hypothetical distribution of stars, according to some rational conception.

Miss Clerke sums up the consensus of various investigators in the "conclusion that the main part of the annular structure we call the Milky Way lies at a distance from us intermediate between the distances belonging to the tenth and fourteenth stellar magnitudes."‡

If the 10·3-magnitude companion of Sirius,§ which is a body somewhat more massive than the Sun, but giving less than $\frac{1}{100}$ of the Sun's light, were to be transported to the distance which I have assumed for the nearer streams of the Milky Way, or had its parallax diminished from 0″·37 to 0″·05, it would fall below the average brightness of the above definition.

Hitherto, attention has been paid almost exclusively to a few thousand exceptional stars of more than ordinary brightness; but let us now consider rather the millions of insignificant stars—stars which are better represented by the companion of Sirius than by its principal star.

Let us first make the supposition that we are dealing with a spiral structure, equivalent to two concentric rings; the inner, at a distance of sixty light-years, and of such section that its volume is thirty thousand cubic light-years, is supposed to consist chiefly of thirteenth to fourteenth magnitude stars; while the outer ring is at a distance of one hundred and eighty light-years, with both section and distance three times as great, or has a volume of two hundred and seventy thousand cubic light-years, and is composed mainly of stars from the fifteenth to the sixteenth magnitude. These values may be approximately included in a zone 10° wide for the inner ring and 6° wide for the outer ring, or, considering that there is much irregularity in both density, width and grouping, we may take for the width an even ten degrees.

The area covered by the rings constitutes nearly one-eleventh of the entire sky, or nearly three thousand six hundred square degrees, and contains much the larger number of very faint stars; but as far as the ninth magnitude, there is little extra richness. Newcomb found seventy-seven thousand three hundred and seventy stars to the ninth magnitude north of the equator, or about one hundred and fifty thousand stars for the entire sky, of which one hundred and twenty thousand may have been between eighth and ninth magnitude. Our galactic zone includes about one-tenth of these. The star-ratio, × 3·85 per magnitude, has been found for the first nine magnitudes in the galactic part of the sky, and it continues to represent the rate of stellar increase tolerably well as far as the fourteenth

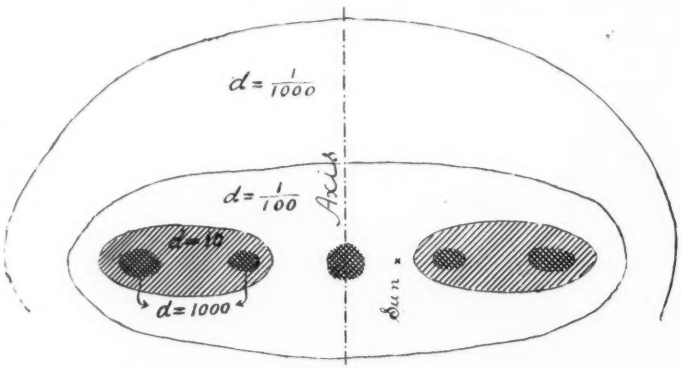

FIGURE 359.

* Miss Agnes M. Clerke, "The System of the Stars," 1st Edition, page 314, 1890.

† G. W. Ritchey, *Yerkes Observatory Publications*, Vol. II, Plate XXVII.

‡ *Op. cit.*, page 366.

§ Magnitude given by E. C. Pickering, *Annals Harvard Observatory*, Vol. XI., page 281.

magnitude in this region, but diminishes rapidly for stars beyond the sixteenth magnitude. This is represented in the following table, where terminal ratios are assumed which express the apparent fact that the star numbers have begun to diminish.

Limits of magnitude	8—9	9—10	10—11	11—12	12—13
Star-ratio ...	×3·85	×3·85	×3·85	×3·85	×3·85
Number of included stars	12,000	46,000	177,000	680,000	2,600,000
Limits of magnitude	**13—14**	**14—15**	**15—16**	**16—17**	**17—18**
Star-ratio ...	**×3·85**	**×3**	**×3**	**×8/9**	**×7/8**
Number of included stars	**10 Million.**	**30 Million.**	**90 Million.**	**80 Million.**	**70 Million.**

The outer ring is three times as far away as the inner by assumption, and if of identical constitution, it should be one-ninth as bright. Since there is approximate equality between the rings, I have made the outer ring nine times as great as the inner. Taking the sums of the included numbers, we have:

$$\text{Inner ring} = 10\text{th to } 14\text{th} + \frac{14-15}{2}\text{ mag.} = 13\cdot5\text{M} + 15\text{M} = 28\cdot5\text{ M.}$$

$$\text{Outer ring} = \frac{14-15}{2} + 16\text{th to } 18\text{th mag.} = 15\text{M} + 240\text{M} = 255\cdot\text{M.}$$

Number of stars per cubic light-year:

Inner ring = 28,500,000/30,000 = 950.
Outer ring = 255,000,000/270,000 = 950.

The star density is nearly one thousand per cubic light-year. The total number of stars in the galactic zone, 10° wide, is 255M + 28·5M = 283,500,000, or 79,000 stars per square degree for the combined rings. A direct count on the photograph gave 78,000, which agrees well enough. The distribution of stars (tenth to eighteenth magnitudes) among the magnitudes, may be represented by the sum of two curves, one for each ring, as given in Figure 358. The dotted line gives the star numbers resulting from the compounding of stars in two rings whose separate numbers are represented by the curves, r_1, r_2, whose maxima correspond to about the fourteenth and sixteenth magnitudes respectively.

Admitting that the Sun is situated midway between two galactic condensations in a vacant, yet somewhat central, region, an ideal axial section of the Galaxy, which harmonizes known facts, is given in Figure 359.

The star-ratio per successive magnitude is equal to the ratio of brightness of stars one magnitude apart, raised to the 3/2 power, or to $(2\cdot512)^{3/2} = 3\cdot981$, provided the distribution is uniform. H. H. Seeliger, from the stars of the Bonn Durchmusterung and of the Southern Durchmusterung to the 9·5 magnitude, found the star-ratio per magnitude = 3·85 for the Milky Way, but only 3·28 for the galactic poles. The variation demonstrates that the stellar distribution in distance, or in brightness, or both together, cannot be uniform: evidently, the limits of the Galaxy have been reached for 9·5-magnitude stars, at least in a direction perpendicular to the plane of the Milky Way. This becomes still more noticeable in a comparison of Pickering's list of stars within 2° of the North Pole with the theoretical star-ratio, from which Ranyard concluded that "instead of over fifteen thousand stars between the fourteenth and fifteenth magnitudes, there are less than four hundred, or only about one four-hundredth part of the calculated number; in other words, about the number of stars which, according to the space-ratio, would lie between the 9·5 and 10·5 magnitudes."* Either we must suppose that there is an absorption of light in space much greater than even that which I have attributed to the distant nebulae, or else the Galaxy is much more restricted than has been supposed. A range of at least ten magnitudes is known to occur in stars whose distances are not dissimilar; hence there is no need of assuming that the excessively faint stars which are massed in the Galaxy must be at distances of thousands of light-years. Neither the faintness of the light, nor the absence of proper motion, is a sufficient reason for rejecting the plain teaching of other modes of investigation.

But in "KNOWLEDGE" for January, 1912,† Dr. Crommelin gives a stronger argument, which we must examine more critically. He says: "It is fairly well established that the Sun moves through some four astronomical units per annum, which, if unforeshortened, would give a star of sixty light-years distance an apparent motion of one-fifth of a second per annum; the galactic stars certainly show no motion approaching this amount, whence it appears certain to me that the Galaxy is far more than sixty light-years distant, so that all Professor Very's estimates of nebular distances would need muliplication by a considerable factor."

In my previous papers I have assumed that our sun is itself a member of the galactic multitude, though remote from the nuclei of condensation, and that an unknown portion of the supposed solar motion is common to the system and may be shared by large numbers of the galactic stars; that is to say, no parallactic motion whatever would be found if the Sun had the average motion of a galactic star, and if the number of comparison stars could be made indefinitely great.

To find the mean galactic motion, in this case, it will be necessary to make a critical study of the proper motions of the fainter and more distant white nebulae from which the apex of the motion of the Galaxy as a whole may eventually be recovered.

The accepted value of the Sun's motion through space has been derived from the relative motions of a few neighbouring stars, assuming that, on the whole, these are moving among themselves indis-

* "Old and New Astronomy," page 725.

† Vol. XXXV, page 31.

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criminately in every direction; that is to say, the investigation of the parallactic and proper motions of the stars has hitherto proceeded on the assumption that the proper motion of a star is as likely to be in the direction of one of three rectangular axes as in any other, and consequently that, in a general average, the components of motion are equally distributed between the three axes. If the assumption is erroneous, the method fails, or at least requires extensive modifications. It has now been definitely ascertained that the assumption is wrong and that the stars are not moving indiscriminately. In 1905, Mr. F. W. Dyson announced the discovery of two great star-drifts which have been traced in his subsequent investigations through all parts of the sky. The stars belonging to one of these drifts diverge from R.A.=270°, D=+12°; and this drift has been mainly influential in the derivation of the accepted value of the solar apex. The other great drift diverges from R.A.=83°, D=+60°. The phenomenon has the appearance of an interpenetration of two great star streams coming from directions 110° apart.

As a consequence of this discovery, we must consider the possible alterations which it may impose upon the value derived for the solar motion. Stars in a stream whose motion is opposed to the Sun's movement, will open out more rapidly in the direction of the Sun's advance than members of the stream to which the Sun itself belongs. The latter may be advancing together on nearly parallel lines and with nearly equal velocities, and may thus maintain relatively fixed distances from each other and from the Sun, with an almost total absence of proper motion, although relatively near to us. The selection of stars having large proper motions as suitable candidates for parallactic determination may have to be revised in the light of this new conception. If stars without sensible proper motion are investigated for parallax with the same assiduity as those of large proper motion, we may perhaps find some near neighbours in this neglected group.

The phenomenon to which Proctor gave the name of "star-drift," has been known from a few isolated groups. The conception must now be extended. What we have done is to select a particular drift among stars of large apparent motion, which seemed to be somewhat general, namely, that in the direction of the constellation Argo, and to assign its cause to the motion of the Sun, and we call this the general parallactic motion; but there has been, until quite recently, no way of deciding which of these movements—that of the Sun in the direction of Lyra, or that of the other stars in the direction of Argo—is the real one; and no matter whether the peculiarity is one of solar motion or of solar rest, it is the Sun's own peculiar condition as compared with that of a considerable body of stars.

Now, seeing that other stars move in groups, is it reasonable to suppose that our Sun has no companions to share in a common drift? There is a great multitude of stars with scarcely any appreciable proper motion, including many stars which are fairly bright. Is it necessary to suppose that these are all at such a great distance that their proper motions are insensible on this account? May not a great many of them fall into one common star-drift with our Sun? If so, it is the "Argonauts" that are peculiar. Actually, the direction of stellar motion away from the solar apex may not be the predominant one. We begin to have evidence of this solar association. Professor Stroobant* has chosen stars with moderate annual proper motions (0″·00 to 0″·08), namely, α Cassiopeiae, β Persei, α Persei, α Scorpii, γ Cygni, ϵ Pegasi, α Pegasi and the Sun, and by combining the parallax, the motion in the line of sight and the proper motion, he gets a true picture of their system in space and finds that these eight bodies agree in the direction of motion within a range of about 6°, while their velocities range between 11·3 and 22·1 kilometres per second.

Professor Lewis Boss finds evidence of a great star drift towards R.A.=95°·6, D=−7°·5†, to which Mr. Benjamin Boss assigns a mean linear velocity of ninety-five kilometres per second. I understand that this investigation is merely a preliminary one. Since it rests upon the supposition that there is but one great drift, and that the direction and amount of the solar motion is that commonly assumed, the foundation becomes insecure, as soon as divers other drifts are admitted to exist. Mr. Benjamin Boss refers to the drift of "the Taurus group in the general direction of the vertex (inclined to it about 15°), and the Ursa Major group inclined about 18° with the antivertex,"‡ but the effect of these and other drifts upon the assigned solar motion is not considered.

Mr. H. C. Plummer gives preliminary data for several new star-drifts.§ He finds

	No. of Stars.	Velocity km./sec.	R.A.	Dec.
Drift i. ...	22	9·7	65°·2	−24°·4
„ ii. ...	19	37·9	87°·0	+ 7°·3
„ iii. ...	16	21·6	106°·1	−52°·9
„ iv. ...	13	10·0	317°·2	−23°·6

No. ii. agrees with Mr. Boss's value for the Taurus group which is shown to be "no mere localized cluster, but contains members which are scattered over the whole sky." No doubt many other drifts remain to be discovered.

(To be continued.)

* *Bulletin Astronomique*, November 1910, Vol. XXVII, page 433.

† *Astronomical Journal*, No. 629, page 33, November 20th, 1911.

‡ *Astronomical Journal*, No. 629, page 33.

§ *Monthly Notices Royal Astronomical Society*, Vol. LXXII, No. 3, page 170, January 1912.

NOTES ON THE DEVELOPMENT OF MONADIDEA.

By AUBREY H. DREW.

BIOLOGY is as profoundly concerned with the study of the smallest, as with that of the largest organisms, but the class Mastigophora deserves special attention from microscopists for many reasons. The discovery of the Trypanosomes, and their intimate relation to sleeping sickness and many other diseases peculiar to tropical regions, has concentrated a considerable amount of attention on the Trypanomorphidae, and numerous biologists are engaged in all parts of the world in working out their life-histories. The order Monadidea, which comprises the least differentiated forms of the Mastigophora, is well worthy of careful inquiry, as, although at present none of this order have been demonstrated to be the causative agents in disease, yet they are allied to the Trypanosomes, and in them we have a type of organism which is on the very fringe of organised life. The opportunities for discovering new and interesting forms are great, as the order has been very much neglected, and comparatively few of the organisms have been figured and described. Moreover, it is extremely desirable that we should possess a full knowledge of the life cycles of the Protozoa, and an excellent field is open in this direction to microscopists. It is not difficult, I think, to understand why this order has been so much neglected, as the organisms comprised therein are exceedingly minute and consequently escape the notice of the average amateur microscopist, unless he is provided with first class and high powered lenses. The professional worker is usually so taken up with organisms such as the bacteria that, even if he comes across the monads in the course of his researches, he has no time to spare for organisms that are not yet definitely connected with disease.

Again, to acquire any real knowledge of the development of these minute forms, it is necessary to spend long and wearisome hours of constant observation at the microscope, and the majority of workers prefer a study that does not tax their patience to the uttermost. It is, however, to the amateur, who has already done yeoman service to microscopic science, that we must look to work out these organisms, and with such a wide and little explored field before them it is much to be hoped that ere long our knowledge of these organisms and their wonderful life cycles will have greatly advanced. The Monads are universally distributed in water containing decomposing organic matter, either animal or vegetable. They are colourless flagellata, with from one to an indefinite number of flagella, and a single nucleus; they also possess a simple vacuole system.

METHODS OF NUTRITION.

The nutrition of the order may be holozoic, saprophytic, or parasitic, but probably never holophytic. Formerly, the Monads were regarded as essentially saprophytes, but increased knowledge of the order, and particularly a careful study of their life histories, has shown that almost invariably a certain amount of holozoic nutrition takes place at some period in the organism's development. In certain forms holozoic nutrition plays a very important part, saprophytism being reduced to a minimum. In the new monad, *Monas sarcophaga*, described by myself in "KNOWLEDGE" in November, 1910, holozoic nutrition is by far the most important means of obtaining food, and in this particular form the organism even goes so far as cannibalism. Some forms, and perhaps all, in a greater or less degree, are saprophytic, obtaining their nutrition from the water in which they live by absorbing the soluble disintegration products from the breaking down of complex protoplasmic molecules by bacteria. The food in these cases is predigested by the enzymes secreted by the various bacteria present. Most forms, however, combine a certain amount of holozoic nutrition with the saprophytic, these organisms being conveniently designated as Mixotrophic. With regard to these mixotrophic forms, bacteria and small protoplasmic particles, both animal and vegetable, form the food, whilst in the *Monas sarcophaga* other monads of the same or different species are ingested.

REPRODUCTION.

Two methods of reproduction occur in the Monadidea, a sexual and an asexual. As is the rule amongst the Protozoa, reproduction by fission is the commonest. Some appear to divide into many smaller forms, as first recorded by the late Dr. Dallinger. The nucleus in all cases appears to go through a karyokinetic process prior to division. This asexual process, however, does not appear to be capable of maintaining the perpetuation of the organisms indefinitely, and in probably all cases an anisogamic method of reproduction also occurs. This is almost always obscure, and can only be observed by continuous and repeated observation of the same form over a length of time. Dallinger recorded that he and Drysdale observed the same form continuously for five days before seeing any other method of reproduction than the asexual. In many, and possibly all cases, the spores which are formed in this method of reproduction appear to be more resistant to heat and other unfavourable conditions than are the parent forms, thus tending to keep the species from extinction. Dallinger and Drysdale recorded that in one form they studied, the parent organisms had a thermal death point of about 60°C, while the spores from the sac did not perish till a temperature of 149°C was reached. I have found also, in the case of the *Monas sarcophaga*, that

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the normal form dies at a temperature between 52°C and 55°C, while the contents of the sac formed by the conjugation of two forms withstood a temperature of 120° C for five minutes. This second method of reproduction does not in all cases appear to be truly anisogamic, for often the two conjugating gametes appear to be similar. In other cases the gametes may differ in some respects—generally, one is larger and more granular than the other. In the forms where holozoic nutrition is met with, a digestive juice of an acid nature appears to be secreted. In the *Monas sarcophaga*, which habitually ingests other monads, as well as bacteria, I have shown that bacilli stained with blue litmus are almost instantly turned red after ingestion. In this particular organism this secretion appears to act with great rapidity, the edges of the ingested organism being speedily corroded, till only a small portion of undissolved material is left, which the monad finally expels.

FIGURE 360.
Normal free-swimming form.

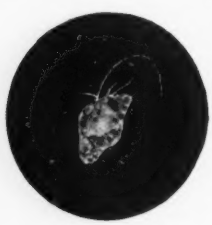

FIGURE 361.
First stage in reproduction by fission.

STRUCTURE.

The structure of the monads is simple. They do not appear to be divisible into an ectoplasm and an endoplasm, like the Amoeba. The organism usually consists of transparent protoplasm, with granules embedded therein. Some of these granules are probably of a fatty nature, staining black with osmic acid. All the monads possess a nucleus, which is at times specially prominent. Even in the holozoic forms no mouth opening or anus is present, but in some species food particles are ingested at certain fixed points, usually at the base of the flagella, whilst undigested matter may be expelled from any point in the body, but usually from the opposite end to the flagella.

FIGURE 362.
Second stage in reproduction by fission.

METHODS OF STUDY.

A few words on the methods adopted in the study of these organisms may be useful. The microscope used for this class of work must be a firstrate one. It should have a tripod foot, and be perfectly steady in any position. A mechanical stage and compound substage are absolutely necessary. The microscope that I have used exclusively for my researches on these organisms is one of Messrs. Watson's instruments, and although it has been in daily use for over four years I have not found it necessary to make the slightest adjustment. With regard to lenses, these need not be numerous. The objectives I have found to be of most utility are the half-inch, one-sixth inch, and one-tenth inch dry, and one-twelfth inch homogeneous immersion. A high-powered dry lens is essential for a large part of this work, as an immersion lens is objectionable when following a rapidly swimming organism for many hours. The one-tenth inch dry lens that I have used for some time was made by Watson's, and is an excellent lens for this work, possessing the three necessary requisites, *viz.*, excellent definition, capability of bearing a large solid cone from a good condenser, and ability to take high eyepiecing. The condenser used should be an achromatic one, the Abbé Illuminator being useless for critical work. The first requisite is some means of keeping a minute drop of fluid, containing the organisms, continually moist, and to prevent evaporation. Perhaps one of the best means is that devised by the late Dr. Dallinger, and described in "The Microscope and its Revelations." A very good arrangement I have used and which possesses the advantage of allowing several objectives on a revolving nosepiece to be used rapidly, is the following. A piece of thin cardboard has a circular hole cut out of it, and the card is then cut to a slightly smaller size than the ordinary three-inch by one-inch slide. This prepared card is then soaked in water, the excess of water removed, and the card placed upon a glass slide. Two cover glasses are used, one slightly larger than the hole in the card, the other being quite small, say three-tenths of an inch in diameter. The drop of fluid to be examined is placed between these cover glasses and they are then placed on the card, the smaller cover glass being undermost; if a small vessel of water is now placed in connection with the card by means of filter paper the preparation may be kept for weeks without evaporation from the fluid under examination. It is almost impossible to get good permanent dried preparations of the monads, as if dried on a cover-glass, like bacteria, they break up, and the same result occurs if fixing agents are used; hence it is extremely difficult to photograph the organisms, and recourse must be

FIGURE 363.
Third stage in reproduction by fission.

FIGURE 364.
Resting stage prior to conjugation.

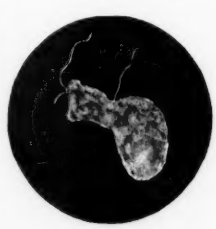

FIGURE 365.
Conjugation.

had to the "Camera Lucida." Movement may be stopped by very dilute solutions of cocaine hydrochlorate. The drawings illustrating the life history of the monad herein described were done by means of a Camera Lucida and Watson's "Holoscopic Immersion Paraboloid" which gives excellent dark-ground effects with high-apertured lenses. Whilst engaged in working out the life history of the *Monas sarcophaga* I frequently observed small organisms somewhat resembling this monad, but of considerably less size and possessed of a peculiar jerky motion in swimming. The difficulties in working out this organism's life history were not a few, but at length I have been able to accomplish it. This monad is an entirely new one, and on account of its peculiar vibratory motion in swimming I have named it *Monas vibrans*. This organism is closely related to, and belongs to the same sub-tribe as the *Monas sarcophaga*, *viz.*, the Paramastigoda. It varies slightly in size, but not nearly so much as the *Monas sarcophaga*, the average size being about one four-thousandth of an inch in length. The shape is bluntly triangular or conical, and the organism is very granular. It possesses two flagella, one long and one short (hence Paramastigote). The long flagellum is not as long in proportion to the body as that of the *Monas sarcophaga*, and is bent round somewhat like a fish hook; the small flagellum, which is exceedingly minute, and generally rather difficult to observe, arises from the base of the long one, and on its convex side (see Figure 360). A nucleus, which stains somewhat irregularly with Haematoxylin, and a contractile vacuole are present. Swimming occurs by lashing of the long flagellum, aided by the smaller one. The long flagellum is vibrated with a peculiar whip-like motion which makes swimming very jerky and irregular. On following one of these forms by means of the mechanical stage, never losing sight of it in all its wanderings, it is found after a varying period to come to a standstill, and to adhere to the slide, apparently by means of a pseudopodial appendage. On coming to a rest, the long flagellum is vibrated with great rapidity, thus causing small protoplasmic particles and bacteria to be swept towards the monad, many of which on touching the body, near the flagella, are engulfed by an amoeboid action of the protoplasm. This stage of feeding may last for hours; in fact, the monad spends a large part of its existence in feeding in this way, swimming about at intervals apparently in search of pastures new. After some time two new flagella slowly appear near the normal pair. At first, these are very minute but rapidly grow larger and are in intense vibration; they swiftly diverge and at length get to the opposite pole to the normal pair. During this duplication of the flagella, the nucleus of the organism has become strongly developed and a division takes place; one of the two daughter nuclei now passes into each polar region, and with the two pairs of flagella now pulling from opposite ends a constriction suddenly appears across the body of the monad. From this time onward the constriction rapidly deepens, the two pairs of flagella pulling the organism into an hour-glass shape, shown in Figure 363. Finally, only an exquisitely-fine strand of protoplasm connects the two halves; this strand gradually gets thinner till at length it snaps, and the two organisms go free. Usually one of the two remains in the place where division took place, and at once commences to feed, while the other swims about for a time, till it also becomes stationary, and commences feeding operations. In a few instances I have observed feeding to go on during the actual process of division. The time occupied in this division is usually from fifteen to twenty minutes. For many months this was the only method of reproduction which I could observe. At length, however, I found that a certain proportion of the organisms, after swimming and feeding in the manner already described for many hours, became very sluggish and usually sank to the bottom of the drop of of fluid under examination; the flagella lashed feebly, and the body of the monad became very pale and rather indistinct, the nucleus becoming considerably more prominent than usual and situated towards the posterior end of the monad. In several specimens I have noticed that the nucleus became somewhat striated at this stage. Finally, the flagella ceased movement, and the whole organism was perfectly motionless. At first, I came to the conclusion that some deleterious influence had killed the monad, and it was only after I had again and again failed to find any other method of reproduction than the asexual, that I determined to study these motionless forms further. A peculiarity of this monad is the length of time that it may remain in this quiescent condition. In four specimens I observed the average

FIGURE 366.
First stage in formation of sac.

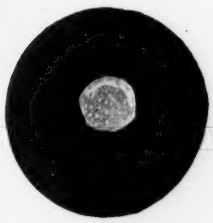

FIGURE 367.
Second stage in formation of sac.

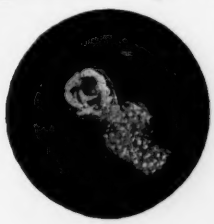

FIGURE 368.
Sac discharging spores.

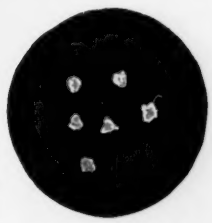

FIGURE 369.
Spores after four hours growth.

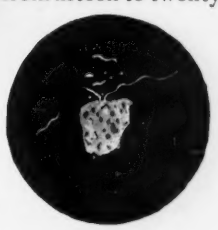

FIGURE 370.
Sedentary form feeding.

duration was about three and a half hours. The flagella then suddenly commence to lash again, at first very feebly, but finally rapidly, and the organism swims off. During the quiescent period, the body of the monad has become swollen and very pale, and the nucleus dense and glistening. These organisms now swim about with great rapidity. If one is now carefully followed, it will be found, after a varying lapse of time, to seize on one of the normal forms, to which it adheres, violent lashings of the flagella taking place. It is soon evident, however, that the larger organism is absorbing the smaller. Finally, this is accomplished, and very soon after this the monad, or more properly speaking the product of the fusion of the two organisms, comes to a standstill, rapidly gets globular, the nuclei disappearing and the flagella melting into the sarcode. A motionless globular sac is now left, of a slightly yellowish colour. The time the sac remains in this condition apparently varies a good deal, perhaps owing to temperature, but thirteen to fifteen hours seems about an average. It then suddenly and without the slightest warning bursts, and a glairy fluid, containing excessively minute granules, is poured out. These granules at first show only Brownian movement, but later (about three hours) they grow somewhat larger, and then exhibit amoeboid movements. From this time they rapidly grow larger, minute flagella are developed, and they swim away, small but perfect counterparts of their parents. It will be seen that this organism, both in its microscopic appearance and development, bears a striking resemblance to the *Monas sarcophaga*. It is easily distinguished, however, by its much smaller size, and the difference in the flagella. The average size of these organisms is very uniform, whilst the *Monas sarcophaga* shows considerable variations. Although I have specially and carefully looked for it, I have never found this monad to ingest other monads either of the same or different species. This, I think, is to be accounted for by two reasons. Firstly, the small size of the organism, and secondly, the flagella being smaller, do not appear to set up sufficient current to draw bodies of much greater size than bacteria towards the monad. A large number of these organisms furnish the *Monas sarcophaga* with food, and on several occasions I have had many hours' work spoilt by the monad under investigation finding a grave within the body of the former organism. Both these monads are, I believe, found exclusively in putrefying vegetable infusions and ponds in which much vegetable matter is in process of decomposition. The *Monas vibrans* multiplies far more freely and rapidly than the *Monas sarcophaga*. Both organisms may be cultivated in infusions of grass, but both rapidly die out as soon as the larger infusoria appear. The *Monas vibrans* almost invariably disappears from an infusion before the *Monas sarcophaga*, and from a large number of experiments I have come to the conclusion that both these organisms produce substances in the culture medium, which act deleteriously on them, and ultimately inhibit growth. I have recently found that if a quantity of an old culture, in which the organisms are dying out, be exposed to a temperature of 60° C. and then filtered, the filtrate possesses markedly toxic properties towards these monads, a minute quantity added to a hanging drop preparation soon causing death. I am inclined to think that the toxic substances are of the nature of ferments, though at the present stage of my researches I cannot bring forward any direct evidence to support the view.

CORRESPONDENCE.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—In a reply to Mr. Annison's article on the Fourth Dimension appearing in your issue for July, 1912, I notice a reference to a letter of mine on the subject which appeared in "KNOWLEDGE" for August, 1911. This letter merely called attention to an argument I had propounded in favour of the real existence of the fourth and higher dimensions in an earlier issue of "KNOWLEDGE," and had more fully stated in Chapter VI of a work of mine entitled "Matter, Spirit and the Cosmos" (Rider, 1910). I gather from his remarks, however, that Mr. John Johnston, the writer of the reply to Mr. Annison's paper in question, has merely read my letter appearing in "KNOWLEDGE" for August, 1911, and has not consulted the statements of my argument therein referred to. It seems to me very unwise, to say the least, to venture a criticism of an argument with which one is not acquainted. It is, of course, obvious, to use Mr. Johnston's illustration, that a third apple on a boy's table does not imply the existence of a fourth; but then, the existence of one apple on a boy's table does not imply the existence of a second, nor does the existence of a second imply that of a third. The case, however, is altogether different with regard to the dimensions of space; for it can be argued, as I have shown in the places referred to, that the existence of one dimension of space does imply that of a second, and that the existence of a second dimension does imply that of a third. By the principle of the continuity of law, or the uniformity of nature, or whatever one likes to call it, then, the existence of a third dimension implies that of a fourth, and so on *ad infinitum*. This principle, I would remind Mr. Johnston, is a most valuable one and has led to many valuable discoveries. It consists merely in the assumption (which the whole of our growing experience warrants) that a law holding good in the case of phenomena entering into our experience, holds good also in the case of phenomena which do not as yet, and perhaps never will, enter into our experience. It is the principle, for example, which enables us to predict the rising of the sun to-morrow, and, in fact, lies at the root of all natural science.

Thanking you in anticipation for affording this letter the hospitality of your columns.

H. STANLEY REDGROVE.

THE POLYTECHNIC,
REGENT STREET, W.

CELESTIAL MOTIONS CONSIDERED ON THE PRINCIPLE OF RELATIVITY.

By Col. E. E. MARKWICK, C.B., F.R.A.S.

In astronomical text-books and popular works on the science one frequently, and naturally, meets with references to the enormously swift motions of celestial bodies, as compared with terrestrial experience. We read of the great comet of 1882 "rushing through the part of its orbit closest to the Sun," and the fixed stars are described as in reality "flying through space" at enormous velocities of varying direction and amount. One recalls how, in old schooldays, when "doing globes," the master would ask the question, "How fast is the Earth moving in its orbit?" and the pupil would answer, "Rather more than sixty thousand miles an hour." The first time one heard this it sounded as something startling, but the youthful mind cannot easily apprehend such an enormous speed, and by repetition the fact got to lose its significance. All these statements of high speeds are, of course, true, being based on a solar parallax which is now almost certain to the first decimal, combined with observed motions of the heavenly bodies.

Sir R. S. Ball, a most lucid expositor of celestial facts and figures, remarks in "The Story of the Heavens," on the motion of the Earth: "It will appear that the earth must actually complete eighteen miles every second. Pause for a moment to think what a velocity of eighteen miles a second really implies. Can we realize a speed so tremendous?" He then goes on to compare the motion of the Earth with that of an express train, travelling at the regulation text-book speed of sixty miles an hour, so that the speed of the train "is not even the one-thousandth part of the velocity of the Earth in its orbit." But he continues: "Viewed in another way, the stupendous speed of the Earth does not seem immoderate. The Earth is a mighty globe, so great, indeed, that even when moving at this speed it takes about eight minutes to pass over its own diameter. If a steamer required eight minutes to traverse a distance equal to its own length, its pace would be less than a mile an hour." A figure is given, showing two equal circles joined by a straight line, the distance between the centres being about six times a diameter of the circle. If this represents the Earth at two stages in its path, then "the time required to pass from one position to another is about forty-eight minutes."

The particular point now is to consider some of these enormous, and, to our experience, utterly transcendental speeds, relatively to the size of the moving body, because they then begin to assume a different aspect. A sense of proportion must be brought to bear on the matter, and actual terrestrial motions and dimensions must be more or less kept in their proper sphere when studying the order of motions and dimensions of the solar system as a whole. *Apparent* motions, however, are common to whatever position we are in, or may imagine ourselves to be in. Apparent motion, or, as it may here be termed, angular motion, is the speed at which a body moves across the field of view, irrespective of its distance. If we imagine anyone (call anyone an "ether-man," someone above an "air-man" in powers and qualifications), occupying an isolated position in space, it must still be with this corporeal frame, with a pair of eyes to see, and a celestial object to be seen. The rotation of the ether-man's body round its longer axis still sweeps out a field which is measured by three hundred and sixty degrees for a complete rotation. This conception holds good, even if deprived of the terrestrial horizon.

For the present purpose it seems convenient to fix on some limit of angular speed, below which, at the first glance or so, a body seems to have no motion. It is rather an arbitrary proceeding, but may serve for illustration. Put this limit at a rate of transit of 10° in five minutes of time, or 2′ of arc in one second; *i.e.*, three hours for the tour of the whole horizon. With this angular speed, a terrestrial object at one hundred yards distant from the observer would have to move at the rate of two hundred and thirty-one yards per hour; at two hundred yards, four hundred and sixty-two yards per hour; at one mile distant about two and one-third miles per hour; and at ten miles distant twenty-three miles per hour. For celestial observation, consider an object moving at a less angular speed than this, as seen with the naked eye, to be devoid of visible motion; if it moves faster, then say it has visible motion.

The angular motions of the planets round the Sun, and of the satellites round their primaries, are, of course, far below the limit just fixed. Seen from the sun, Mercury moves about 0″·17 in one second, the Earth 0″·04, Neptune 0″·00025. Turning to the satellites, the rapid Phobos, with its period of seven hours thirty-nine minutes fourteen seconds, moves 47″ in one second. Take, again, the case of a comet moving very close round the Sun. The comet of 1843 is stated to have described the whole of the segment of its orbit North of the plane of the ecliptic, in a little more than two hours. This implies an angular velocity of about 90″ per second. All these rates of motion are below, and most far below, the hypothetical limit.

What then, would a view of the solar system reveal to the ether-man, placed in space at a point

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high above the ecliptic? *Above* the ecliptic is, of course, a *façon de parler*, for there is no up or down, as we use the terms, in celestial matters; what is meant is, on that side of the ecliptic plane in which the north pole of the earth is situated. Let this point be somewhere about twice the diameter of Jupiter's orbit "above" the Sun, so as to open out his orbit and those of the planets within. Imagining our friend gifted with the necessary keenness of vision, at a casual glance the whole of the planets would seem to him to be at rest. There they would be, hung in space, apparently fixed points of light. It would be the same with the several families of satellites, supposing the observer could visit each of the mother planets, and note the outlook thence, as he studied the children of each. With the exception of a few of the satellites he would have to watch some little time before the motions of each system could be detected. Even a few stray comets would appear quite motionless in the inter-planetary spaces. All this is on the proviso that the observer has no telescope, but is watching things with ordinary unaided vision.

The same remarks apply with more force to the stellar system. Here, there is not so much need to move from the earthly point of view, as the Earth is surrounded by the stellar universe in all directions. And what is observed? The configurations of the stars remain practically the same from age to age. For thousands of years the old historic constellations have presented much the same shaped groupings; yet it is certain that every star is in motion—all have their proper motions—moreover, there are streams and classes of motions which individually, and taken absolutely, are of immense magnitude. The real motions of individual stars are known to range from ten miles up to forty or fifty miles per second, and in one case two hundred miles per second. All the while their apparent angular motions are extremely small. The principle of relativity must be borne in mind, and then it is seen that if the movements of the stars are compared with their enormous distances apart, the former are really quite slow and gradual.

Absolute terrestrial movements may, of course, be compared arithmetically with celestial ones, but to really grasp the enormous disparity between them is another matter, seeing we are dealing with speeds beyond our own experience. However, an effort may be made to discuss the case of the Earth's orbital motion, compared with that of an express train, as best representative of each class. Such motions as those of a rifle bullet or projectiles discharged by heavy ordnance, as well as molecular motions connected with light, electricity, and so on, are purposely left out of account. Everyone knows the terrific rush and momentum of a train travelling at sixty miles an hour, as seen from the platform of some country railway station, about twenty feet from the rails. A cloud of steam is first noticed and a distant roar heard, which rapidly increases in intensity. In the course of a few seconds, with a sense of momentum which thrills the spectator, the train, weighing hundreds of tons, dashes by, a wind follows, filling up the vacuum thus caused, and all is over.

Suppose, now, a position is taken up, on a clear day, on some elevated ground, such as the southern spurs of Dartmoor, or the South Downs in Sussex, some miles distant from the railway. From such a point the same express may be watched with a field glass, wending its way along the valleys and over the viaducts of the lower district. How the apparent motion is now reduced! There is the long trail of steam, but by comparison the train seems to crawl along in the distance. It is brought home to one that the sense of motion of a body depends on proximity to it.

This idea is well expressed in the following lines from a poem on the South Downs by Mr. R. Bridges, the reference being to steamships in motion, seen a long distance away.

> I climb your crown, and lo! a sight surprising
> Of sea in front uprising, steep and wide:
> And scattered ships ascending
> To heaven, lost in the blending
> Of distant blues, where water and sky divide,
> Urging their engines against wind and tide,
> And all so small and slow,
> They seem to be wearily pointing the way they would go.

So much for an example of terrestrial speeds.

Is it now possible to place the ether-man so that he can satisfactorily observe the Earth which moves one thousand times as fast as the express? To begin with, the moving body in this case has a diameter of some eight thousand odd miles, and he must be situated, at the very least, four thousand miles from the centre line of the Earth's track, if only to avoid collision, if such can be imagined between an atom of a being and such a vast globe. To get anything approaching a reasonable view of the motion, proportionate, in fact, to the conditions of position at a railway station, he must be placed about twelve thousand miles from the centre of the track. But seen from this distance the Earth's motion would seem comparatively slow; for, as Sir R. Ball says, it would take eight minutes to pass over its own diameter, which from the selected point of view would subtend an angle of about thirty-nine degrees. This corresponds to an angular rate of motion, when near the spectator, of about 5′ a second. This rate, which is certainly above our limit, is yet not fast, corresponding to a body at one hundred yards distance moving across the field of view at a speed of about one-third of a mile per hour. At the first glance the Earth would seem to be moving very slowly, in fact more or less "poised in space." Morally speaking, it is pretty certain that no human being could see such a sight—and live.

So far, motions of revolution only have been considered, but motions of rotation of the planets, although much more rapid, are still below our limit. A person on the Earth's equator, we know, is whirled round, in space, at an absolute speed of over one thousand miles per hour. Yet on account of the smoothness of the motion, and every surrounding

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object, houses, hills, valleys, ocean, atmosphere and clouds moving together, the speed is not appreciated; it is not even experienced. To try for a sense of it, the ether-man must get away from this terrestrial ball at least ten thousand miles, and then the Earth would at the first glance appear motionless, in the matter of rotation. His success would be no better than in his endeavour to watch the speed of the Earth in its orbit.

Hence it may be inferred that although the motions of the solar system, taken absolutely, quite transcend terrestrial molar motions, yet considered relatively to the dimensions of the system they are not what would be termed rapid—far from it. The angular motion of a body round a centre of gravitation is governed by the Keplerian laws; the nearer to the centre, the more rapid the motion. But even in the extreme case of a body revolving round the Sun, just skimming its surface, and of a body doing the same round the Earth, the angular speed is slower than the limit fixed on.

There is one class of bodies, of a semi-celestial nature, of which no account has here been taken, and which, perhaps, occupy an intermediate position, in the matter of motion, between the planets and the Earth, *viz.*, meteors. Here we have a comparatively minute object moving through the atmosphere at a planetary rate, or something approaching it. Owing to comparative proximity, the great speed of a meteor can better be appreciated than the motion of bodies enormously further away. It is far in excess of the limit, the body covering twenty degrees, thirty degrees, or more, of the field of view in a very few seconds. But do we then really grasp the meaning of fifty miles a second, which is the speed of many meteors? If one were really very close to a meteor it could hardly be seen as it passed by, except in the form of a flash of lightning, because its flight is so enormously swift. Yet in the inter-planetary spaces, a swarm of meteors (if their visibility is possible) would at the first glance seem motionless, if viewed from a distance sufficiently great to enable the whole swarm, or ring, to be included in the field of view.

It seems clear, then, that celestial motions take on a different aspect when considered with due regard to the dimensions of the bodies concerned, and the distances which separate them.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

SPECTRA OF FAINT STARS.—Not very much has been done as yet under this heading, but Professor Hale (of Mt. Wilson) has promised to give the preference to Professor Kapteyn's selected areas in his researches. The general type of spectrum of the fainter stars may be inferred by comparing their magnitude on ordinary plates with that given on red-sensitive plates. A series of the latter plates will be taken at Johannesburg by Mr. Innes, and there is a prospect of a corresponding series in the Northern Hemisphere.

It is well known that the proper motions of the brighter stars show a variation depending on spectral type, and it will be of interest to extend the investigation to much fainter stars. Miss Cannon, of Harvard, gives the following average proper motions of stars of magnitude 5·00.—

	Galactic Latitude ± 20° to ± 90°		Galactic Latitude + 20° to − 20°	
Spectrum.	Average Proper Motion.	No. of Stars.	Average Proper Motion.	No. of Stars.
B	0″·021	1	0″·028	9
B5	·025	72	·024	113
A	·062	84	·049	110
A5	·101	38	·067	27
F	·162	38	·091	18
F5	·234	25	·135	10
G	·308	19	·306	11
G5	·357	25	·302	15
K	·139	117	·123	61
K5	·081	12	·042	6
M	·071	15	·029	5

The table shows that stars of the B or helium type are very distant, while those of the G or solar type have much larger proper motions, and are our nearer neighbours.

RADIAL VELOCITIES.—"On Mount Wilson the focal plane spectrograph has produced in a short time an astonishing number of radial velocities of faint stars. The probable error of velocity of a seventh magnitude star with good lines is 0·9 kilometres per second. A solar star of sixth magnitude requires twelve minutes exposure, seventh magnitude thirty minutes, eighth magnitude seventy minutes." Professor Pickering has been making experiments on deducing radial velocities from plates taken with objective prisms, using the Neodymium absorption line. The probable error is over eight kilometres per second, but for statistical purposes this is not serious and is counterbalanced by the wholesale accumulation of material.

Owing to the small absolute velocity of the B or "Orion" stars an attempt was made by Kapteyn and Frost to deduce the solar motion from these stars alone. The curious result was obtained that stars near the Apex gave a solar velocity that differed ten kilometres per second from that given by stars near the Antapex. It was at first surmised that this arose from groups of "Orion" stars having systematic motions of their own, but further research appears to have negatived this suggestion, and the report now gives as the explanation the shifting of spectral lines due to pressure. If this shifting is really so great, it is obvious that many of the published results of radial motions will need revision.

BRIGHTNESS OF THE BACKGROUND OF THE SKY.—Mr. Yntema, of Groningen, has made some important investigations in this field. He finds that the skylight, even on the darkest night, is not wholly due to starlight, but arises in our own atmosphere, perhaps from a permanent aurora. In spite of this obstacle, useful observations of the total amount of starlight are being obtained. Professor Abbot has made some observations on the top of Mount Whitney (fourteen thousand five hundred feet high), to diminish atmospheric illumination. The results are not yet to hand.

It will be seen from these extracts what a large number of collaborators are engaged in work on these selected areas. While the full completion of the plan will be a work of many years, preliminary results of interest are already appearing. The whole scheme reflects great credit on Professor Kapteyn's energy and foresight, and illustrates the value of method in bringing about a rapid advance of our knowledge of the structure of the Universe.

It is incidentally mentioned that Professor Kapteyn is

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revising the star magnitudes of the Cape Photographic Durchmusterung, and that it will soon be possible to refer these to the standard Harvard system, which will greatly increase their value.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

ORIGIN OF VASCULAR PLANTS.—Although Professor Campbell does not in his memoir (on the Eusporangiatae mentioned in last month's "KNOWLEDGE,") discuss the wide question of the origin of the vascular plants as a whole, he re-states the arguments which he has already brought forward in support of his view that *Ophioglossum* represents the most primitive living vascular plant, and that it is connected with the Bryophytes (liverworts and mosses) through the remarkable *Anthoceros* group, which is usually classified with the liver-worts, though differing from all other Bryophyta in some respects.

Setting aside the question as to whether the Ophioglossales or some other Pteridophyte group (such as the Lycopods) are to be regarded as the most primitive of vascular plants, there are several possible views regarding the origin of the higher plants. Of these, the one which has been so ably urged by Campbell himself is that from some form like *Anthoceros*, in which the spore-producing generation remains with its lower portion embedded in the sexual plant, the free-living spore-producing plant of a simple Pteridophyte, not unlike *Ophioglossum*, may have arisen. The first, and perhaps the most important, step required is the production of a root. The sporogonium of *Anthoceros* obtains water and salts from the simple thalloid sexual plant by means of a swollen absorbing organ or foot; above this there is a zone of active tissue, which for a long time adds fresh tissue to the long cylindrical capsule above; through the capsule there runs a central bundle of elongated cells, and the spores are produced in a zone between this and the several-layered capsule-wall, which contains abundant chlorophyll and bears stomata. Apart from its supply of water and salts, which are derived from the sexual plant, the *Anthoceros* sporogonium is self-supporting; if it produced a root and sent this into the soil, it would become wholly self-supporting, and we should, in fact, have something comparable to a simple form of *Ophioglossum* in general organisation. In the case of the existing species of *Ophioglossum*, the simplest type (*O. moluccanum*) has no definite stem, and consists simply of leaf and root. The young sporophytes of *Anthoceros* and *Ophioglossum* show considerable resemblance, both having a massive foot, while the spore-capsule of the former is represented in the latter by the first leaf or cotyledon. Campbell regards this cotyledon, now sterile, as having been, in an ancestral "pro-*Ophioglossum*" a fertile structure.

While one might point out a considerable number of detailed differences between the Anthocerotales and even the simplest of the known Ophioglossaceae, one must admit that this striking hypothesis of a direct connexion between the Bryophytes and *Ophioglossum* involves, on the whole, less formidable assumptions than those which confront the other theories put forward to account for the origin of vascular plants.

INTENSIVE ECOLOGY.—In "Boden und Klima auf kleinstem Raum," published by Fischer of Jena, G. Kraus has produced an admirable work which will doubtless lead to similar researches on various types of plant-habitat. The perusal of much of the literature of Plant Ecology hitherto produced, leaves one very sceptical as to the soundness of the foundations upon which many of the conclusions put forward are based, and for this reason one welcomes the increasing number of memoirs dealing in detail with some selected habitat and analysing as minutely as possible the various factors of the environment—in short, attempts at what may be termed "intensive Ecology."

Kraus first deals with the influence of the lime-content of the soil in his district (Karlstadt-on-Main), upon the flora, and gives the results of analyses, showing the composition of the underlying rocks (sandstone, chalk, loess), subsoil, and soil; the carbonate-content at different depths in the substratum and in areas inhabited by different plants; the lime-content of the various plants themselves, and so on. From these analyses he finds that none of the plants examined occur exclusively on a substratum of approximately equal lime-content; but on the other hand some species "prefer" a high percentage of lime and others a low percentage. Among the characteristic species of the sandstone areas, usually free from chalk, there occur chalk-loving plants in places where some lime is present; in these places the lime-content is usually much lower than in the normal habitats of these plants, and characteristic chalk-plants with high lime-percentage do not grow in such places. Where the sandstone merged into the limestone the author found some cases of typical chalk-plants, like *Hippocrepis* (Horse-shoe Vetch) and *Pulsatilla* (Pasque-flower), growing in places where calcium carbonate was entirely absent; while "calcifugous" (chalk-avoiding) plants, like *Vaccinium* (Bilberry) and *Calluna* (Ling), were found in spots where a fair percentage of chalk was present. In fact, excepting for a few plants which apparently need large amounts of carbonate of lime, Kraus found most of the "calcicolous" species on soil quite free from carbonate, and he concludes that it is not the calcium carbonate, but the physical characters of the soil, that can explain the distribution of the plants.

Of course, the facts that various "chalk-plants" may be found on soils free from calcium carbonate, and that on the other hand species which usually avoid lime may occur here and there on chalk or limestone, have frequently been observed; where calcium carbonate rocks (chalk and limestone) occur alongside of non-calcareous rocks, this wandering of the plants from calcareous to non-calcareous soils appears to be fairly common. Kraus sets out to explain this, and suggests that the most important factors are the dryness and warmth of the chalk-soil. He proceeds to investigate in detail, with elaborate tables, the physical characters of the substratum—soil structure, water content, temperature, relation of soil temperature to air temperature, air temperature at different heights above the surface, atmospheric humidity, and wind. From his careful observations on these points, Kraus concludes that the chalk substratum is by no means uniform, but is a most complex mosaic of parts differing chemically and physically. Each of these parts has its individual characters—its own climate, in the widest sense. Kraus emphasizes the importance of the structure of the substratum, upon which depend the water-content and the temperature, and which determines above all else the nature of the habitat. Among other interesting observations, he points out, as illustrating the dependence of air temperature upon soil temperature, that the temperature is highest at the surface of the soil, and that from this point it diminishes during the day both above and below, while at night it increases upwards and downwards.

ROOT-NODULES IN NON-LEGUMINOUS PLANTS.—Two interesting papers on the structure of bacterial root-nodules in plants not belonging to the family Leguminosae (in which such nodules are apparently always found) are published in the *Annals of Botany* (XXVI, January, 1912) one by Professor Bottomley on the nodules of bog myrtle (*Myrica gale*), and the other by Miss Spratt on those of an alder (*Alnus incana*) and two species of Elaeagnus (*E. edulis* and *E. rhamnoides*).

In *Myrica* the root-nodules are modified lateral roots. The young primary nodules give rise, by branching, to the characteristic cluster-nodules, surrounded by rootlets which grow out through the end of each branch; three branches or secondary nodules arise from the end of each primary nodule, and like it are modified lateral roots; then the central cylinder of the primary nodule elongates and grows through the apex of the nodule, giving rise to the hair-like rootlet. In each mature nodule four zones can be distinguished: (1) the apical meristem; (2) the infection-thread area; (3) the bacterial zone, which includes most of the cortical tissue of the nodule, and consists chiefly of the enlarged cells containing bacteria; (4) the basal zone—the lower end of the nodule, devoid of bacterial cells, but containing numerous cells filled with oil-drops. After the

nodules have branched and reached their full size the bacteria disappear from the bacterial zone, and the basal zone gradually encroaches upon and finally replaces all the other zones. Pure cultures of the bacteria were made, and were found to be identical with *Pseudomonas radicicola*, the organism of the root-nodules of Leguminosae. Young *Myrica* plants grown in sterilised nitrogen-poor soil did not flourish unless they possessed root-nodules; plants devoid of nodules, after infection with a culture of *Myrica* nodule bacteria, developed root-nodules and grew well.

The nodules of *Alnus* and *Elaeagnus* are modified lateral roots, and are perennial structures showing dichotomous or trichotomous branching. They are produced by the infection of the root with the nitrogen-fixing organism *Pseudomonas radicicola*, as in the case of *Myrica*, which enters the root and propagates itself in the cortex as a rod-shaped organism—in *Elaeagnus* it produces a definite zoögloea in the form of a thread-like jelly in which the bacteria are imbedded. The further development of the organism, in both *Alnus* and *Elaeagnus*, gives rise to relatively large spherical bodies, which multiply until they fill the entire cell; under certain conditions these bodies divide into two, then each divides again, until they lose their identity and a group of bacilli remains in their place. Apparently *Pseudomonas radicicola* is polymorphic, the bacillus (rod-like) and coccus (spherical) types being different forms of one and the same organism. In *Elaeagnus* the bacteria are found mainly in the region immediately behind the growing-point; in *Alnus* the bacteroidal tissue traverses the entire length of the nodule. In *Elaeagnus* the food storage cells are found towards the base of the nodule; in *Alnus* there are zones of tissue concentric with the endodermis; in both, the endodermis performs this function. The coccus is apparently correlated with scarcity of available carbohydrate and change of environment; it is much more resistant to the influence of external agencies than the rod-shaped form. The organism is capable of fixing free atmospheric nitrogen when isolated from the nodules, and its presence is undoubtedly beneficial to the plant.

MOLDENHAWER'S WORK: PLANT ANATOMY A CENTURY AGO.—Probably few botanists have noted the fact that this year marks the centenary of the publication of one of the most important works in the history of this science. After the appearance of the classical memoirs by Malpighi (1675) and Grew (1682), which laid the foundation of vegetable anatomy towards the end of the seventeenth century, very little further advance was made in this branch of Botany for over a hundred years. During the interval between Grew's work and that of Moldenhawer, it is true, some interesting contributions were made by Casper Wolff (1759), Hedwig (1782), Mirbel (1802), Bernhardi (1805), and Treviranus (1806). As Sachs justly remarks in his "History of Botany," Bernhardi's observations are decidedly the best in the whole period from Malpighi and Grew to Moldenhawer; for instance, he distinguished pith, bast, and vessels, regarding them as the three chief forms of vegetable tissue, and he correctly explained the structure of spiral and annular vessels. Treviranus discovered the intercellular spaces in parenchyma, though he thought they contained sap and even described its movement.

Johann Moldenhawer (1766–1827) went far beyond his predecessors and contemporaries in the study of plant structure, both as to his actual observations and the accuracy of his interpretations. He first hit upon the happy idea of isolating cells, vessels, and fibres from plants by maceration in water, though he still relied upon somewhat primitive methods—for instance, he mounted delicate microscopic objects in a dry state and simply crushed or picked his preparations to pieces instead of cutting sections and mounting them in water, though the importance of the latter procedure had already been pointed out by previous workers. His best microscope was an English instrument made by one Wright, and gave a magnification of about four hundred diameters. Besides making good use of his maceration method, which enabled him to study the forms of cells and vessels and to make out the structure of these tissue-elements, and the sculpture on their walls, more accurately than had been done before, he made the fortunate choice of working largely with the maize plant, instead of using the complicated and difficult woody stems which had so greatly puzzled the earlier investigators. Moldenhawer laid chief stress from the first on the contrast between the vascular bundles and the cellular ground-tissue, and thus hit upon a fundamentally important fact which set later workers upon the right track. Even more brilliant was his study of the structure of the stem in Dicotyledons, to which he next proceeded, for he was the first to see that the growth of the woody stem can only be understood from the structure of the young parts of the stem, in which there is a ring of isolated bundles. All previous vegetable anatomists had adopted Malpighi's theory of the growth of woody stems—that the outer layers of wood arose by transformation of the inner layers of bast. Moldenhawer, after carefully comparing the structure of young and old stems, rejected this view and thus removed an ancient error which soon afterwards disappeared from botanical literature. This service alone entitles him to an honourable place in the history of Botany. He was the first to demonstrate the real nature of the stomata on the surface of leaves, showing that these are not simply holes in the outer walls of the epidermis cells but apertures leading into the interior of the leaf and surrounded each by two guard-cells.

Moldenhawer's *magnum opus*, and apparently his only work, is a quarto of three hundred and eighty-four pages, entitled "Beyträge zur Anatomie der Pflanzen," and contains six plates of remarkably accurate and well-executed drawings. It was published at Kiel, where he was Professor of Botany, in 1812. Like Mirbel and several other earlier workers in this field, Moldenhawer had his drawings from the microscope made for him by someone else (in this case by a lady friend), on the ground that more correct and trustworthy figures would be obtained if the observer employed other people's eyes and hands, and thus eliminated prejudice and preconceived opinion from the drawings.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

TOXIC ACTION OF OIL PAINTS.—It has long been recognised that painters working with white lead paint are liable to suffer from headache and other specific symptoms, which have been attributed to lead poisoning. In order to ascertain whether any volatile emanations containing lead are given off by such paints, a series of experiments has been made by Professor E. C. Baly (*J. Soc. Chem. Ind.*, 1912, XXXI, 515).

In the preliminary tests brass tubes about a foot in length and an inch in diameter were coated on the inside with a paste of white lead and linseed oil, and a photograph was taken of the spectrum of the light transmitted through the tubes. A comparison of the result with the photograph of the spectrum of the light used proved that volatile emanations capable of absorbing light rays were emitted by the white lead paste, but not by pastes containing zinc white, or basic lead sulphate. In each case the tubes were gently heated to promote the separation of volatile substances.

Further experiments showed that the volatile compound was given off by white lead paints in appreciable quantities at the ordinary temperature, but no definite evidence of the presence of lead in the emanations could be obtained, even by heating four pounds of a stiff paste of white lead and linseed oil in a vacuum, and condensing the volatile products in a receiver cooled with liquid air.

Hence it appeared possible that the poisonous volatile substance might be due to the influence of the combined water in the white lead upon the linseed oil, whereas basic lead sulphate and zinc white, being anhydrous compounds, would not have such an action. The fact that a mixture of lead hydroxide and linseed oil had the characteristic odour of white lead paint soon after mixing, and gave off the emanation more readily than the latter, lent support to the view that the hydration of the lead carbonate was a main cause of the trouble. In other

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tests, too, with mixtures containing manganese dioxide, red lead and lead peroxide, the same volatile compound was also obtained at low temperatures (about 50° C.). It would, therefore, appear that to prevent the formation of the poisonous volatile substance, the pigments used with the linseed oil should contain neither a hydrated compound such as white lead nor an oxidising agent such as red lead. Driers acting by oxidation, such as manganese driers, are also objectionable for the same reason.

By raising the temperature to about 90°C. the poisonous substance was also emitted by pastes containing silica, lead sulphate and zinc white, but the absorption band in the spectrum did not appear at lower temperatures. The relative ease with which the pigments produced the volatile product could be expressed in the following ratios:—Zinc white or basic lead sulphate, ten; white lead, one hundred and fifty; and lead hydroxide, two hundred and fifty.

The general conclusion was that the poisonous compound was given off by any paint containing an oxidising agent, and that the symptoms experienced by people living in a freshly-painted house must be attributed to this substance and not to specific lead poisoning.

Apparently it consists of an unsaturated aldehydic compound formed from the oil, and the means of preventing its formation are to replace white lead in the paint by basic lead sulphate or zinc white, and to have as little driers as possible in the mixture.

PREPARATION OF NITRATES FROM THE ATMOSPHERE.—Mr. E. K. Scott, writing in the *Journ. Roy. Soc. Arts.* (1912, LX, 645), gives an outline of the present state of the industry of obtaining nitrogen from the air. With reference to the Birkeland-Eyde process, it is mentioned that the factories now possess installations of two hundred thousand horse power, which will be increased by fifty per cent. during the next four years. The towers employed to absorb the nitrogen peroxide produced have been very greatly reduced in size by the use of special packing material of earthenware instead of quartz fragments. The installations now at work or in process of building are capable of producing over two hundred and fifty thousand tons of calcium cyanamide (nitrolim) per year. The development of the industry in this country is checked by the want of a cheap source of electricity for the working process.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE ALKALINE IGNEOUS ROCKS OF AYRSHIRE.—Recent researches by the writer have shewn that the intrusive igneous rocks of the Ayrshire Carboniferous, hitherto designated simply as "dolerites" on the geological maps, include a rich variety of petrographic types, some of which are new (*Geological Magazine*, February–March, 1912). They form a homogeneous suite which can be shewn to be connected with a volcanic episode at the close of the Carboniferous period, the remains of which form a small basin-shaped area of lavas in the district about Mauchline and Tarbolton.

The rocks of this petrographic province are, in general, of basic character, and are rich in alkalies and combined water. The retention of water in an alkali-rich magma has resulted in the rocks of the suite being characterised by analcite, a mineral whose claim to be regarded as an original constituent of igneous rocks has not long been admitted by the majority of petrologists. Many of the other minerals are also rich in alkalies. Soda-pyroxenes and amphiboles and nepheline are abundant in some of the rocks.

The intrusive rocks occur as stratiform sills, small lenticular masses, and as plugs and irregular intrusions in volcanic necks. Petrographically, they are classified as follows:—

A.—Rocks with conspicuous analcite.

B.—Rocks with conspicuous nepheline.

C.—Rocks without conspicuous analcite or nepheline, but which may contain either as an accessory constituent.

The most abundant rocks of the first group, and of the whole suite, are the *teschenites*, gabbro-like rocks characterised by abundant analcite. Occasionally these assume ultra-basic modifications, and are to be described as *picrite*. Some of the picrite-teschenite masses shew the most extraordinary differentiation, many distinct types being found in the same igneous unit. Some of the analcite rocks are new to science, notably one called *lugarite*, from its type-locality of Lugar. This rock contains nearly fifty per cent. of analcite and nepheline, the remaining half being composed of soda-pyroxenes, amphiboles, ilmenite, labradorite and apatite. Another rare variety is *analcite-syenite*, characterised by the combination of analcite with alkali-felspar, and strictly analogous with the nepheline and leucite syenites. This rock is remarkable for its extreme freshness and for the abundance of aegirine, a soda-pyroxene rare in Scotland. A monchiquite, with huge phenocrysts of hornblende and biotite, completes the analcite-bearing suite, and has been described at length in a former note ("KNOWLEDGE," Vol. XXXIV, page 405). The nepheline-bearing rocks include *essexite*, *theralite*, hitherto unknown in Britain and remarkably fresh, and *kylite*, a new type which may be characterised as an olivine-rich, ultrafemic theralite or essexite, and so named from its abundance in the Kyle district of Ayrshire.

The rocks belonging to the third group may be called *alkali-dolerites*. They include numerous and varied doleritic types, characterised by purple soda-bearing pyroxene and accessory analcite or nepheline.

The lavas of the Mauchline basin consist mainly of very basic olivine-basalts, but certain of the types contain a good deal of original analcite, and may be designated *analcite-basanite*. Others contain fresh nepheline, and are true *nepheline basalts*. Recently, nepheline basalts fully as fresh and perfect as any of the Continental Tertiary examples have been found in the river Ayr, near Mauchline.

These rocks form a petrographic province whose boundaries are approximately those of the county of Ayr, although some part of it may be faulted down beneath the Firth of Clyde.

THE SEARCH FOR POTASH IN THE UNITED STATES.—Practically all the potash salts of mineral origin consumed in American industries are imported from Germany, which is the only country where potash mines are profitably worked. As the potash salts imported into the United States in 1910 cost nearly twelve million dollars, and this amount may be expected to increase rapidly in the future, the alert and efficient Geological Survey of that country set itself to discover whether the United States could not supply, at least partly, the needful potash, and thus break down the German monopoly which results in enhanced prices.

Among the available sources of mineral potash are the potash-rich igneous rocks which contain minerals such as leucite and orthoclase. The largest area of leucite-bearing rocks in the United States embraces the Leucite Hills of Sweetwater County, Wyoming. These have been investigated by Messrs. Schultz and Cross, and the results published in Bulletin 512 of the United States Geological Survey. A brief description of the leucite rocks is given, with an estimate of the amount of potash these rocks may be expected to yield when a suitable process for extraction has been discovered. The latter is now a problem for the technological chemist and the industrial engineer. Several reduction processes for extracting potash from igneous rocks have been patented; but, so far, none have proved commercially successful. The amount of potash stored in the lavas of the Leucite Hills is estimated at nearly two hundred million tons.

The mineral alunite, a sulphate of potash and alumina, is also used as a source of potash. An important deposit of this mineral, which promises to afford one source of the much-desired potash, has recently been discovered near Marysvale, Utah. It is described in Bulletin 511 of the United States Geological Survey. The alunite forms a banded vein cutting, at a steep inclination, the volcanic rocks (andesite and dacite) which form the greater part of the Tushar range. It is a fissure filling, not a replacement of the country rock, and has a typical banded or crusted structure. The vein has been

proved for three thousand five hundred feet, and in that distance drops from an elevation of eleven thousand to about nine thousand nine hundred feet. This may be taken as good presumptive evidence of a corresponding continuity of the deposit in depth. At a conservative estimate this deposit would yield thirty thousand tons of potash (K_2O) for each hundred feet in depth. This is approximately one-sixth to one-seventh of the total annual consumption of potash in the United States.

METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

GLOBULAR LIGHTNING.—An interesting account of this somewhat rare phenomenon has been furnished by Mr. S. Biggs, of Mazoe, South Rhodesia, who reports that in September, 1910, at about 9 p.m., he observed a ball of fire, the colour of an electric light, about one foot six inches by ten inches in size, and similar in shape to a Rugby football. The ball was luminous and transparent, but it cast no light beyond its own body. When first seen it was stationary over a road on Mr. Biggs' farm, and it remained in one position for about five minutes, during which time Mr. Biggs approached within three yards. The light then moved away in a zig-zag fashion at a rate of about six miles an hour, and finally entered a belt of trees, where it disappeared, leaving no trace whatever of its flight. No noise was heard, no trace of damage could be found, and no smell could be detected.

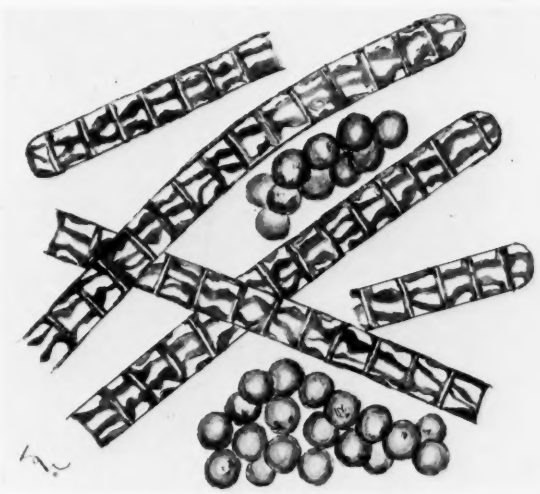

FIGURE 371.

Oscillatoria agardhii Gom.

MICROSCOPY.

By F.R.M.S.

A BLUE SCREEN.—Take an unexposed process plate; fix it out in the dark with "hypo"; wash well. Now fix the gelatine film with formalin (ten per cent. or any convenient strength) as if it were a histological preparation; this may take several hours. Wash well and stain with aqueous solution of saureviolett (Grubler). Wash and dry. An excellent screen is thus produced, which will transmit only the blue and about half of the green. The intensity is modified by the completeness of the formalin fixation, but if this is omitted the results will be very unsatisfactory. The best plan is, therefore, to give plenty of time. I made my staining solution by adding water to a saturated solution of the dye-stuff (which appears to be disulphonated dimethyldiethylpara-rosanilin) in seventy per cent. alcohol. The time of staining varies according to circumstances: it is, perhaps, best to leave the plate until no further staining action is observed.

E. W. BOWELL.

MILES OF GREEN WATER.—Anyone who noticed the Regent's Canal in July must have been struck by the colour of the water. From the bridges it appeared of a dark green, quite unlike its usual aspect. From the tow-path the water was seen to be full of flocculent matter, diffused through it; but in corners and where the sluggish current was checked by barges or other obstructions the minute bodies collected and formed masses, floating on the surface like thick green grease or paint. The appearance was caused by the presence in astonishing quantities of a minute plant, one of the blue-green algae, an *Oscillatoria*; namely, *O. agardhii* Gom. This consists of extremely thin threads of various lengths, composed of cells, filled with pale green protoplasm. It is this which gives the colour, so noticeable owing to the immense number of the organisms. The cells have also in them several variously shaped, highly refractive bodies (see Figure 371), generally considered to be "gas vacuoles." Like other oscillatorias this one has a motion of its own, in addition to that afforded by the flow of water. It bends slightly backwards and forwards (oscillates — hence the name), and also progresses slowly through the water. It measures from four to five microns in diameter. In 1909 the same organism was present in the reservoir at the Welsh Harp, Hendon, in a similar manner. *Vide Journal of the Quekett Microscopical Club*, Series 2, Vol. XI, No. 67, page 115, *et seq.* I was told that the outbreak extended for more than twenty miles through the canal. There were present also considerable numbers of a minute spherical alga, with a very similar colour. It collects into irregularly-shaped bodies of different sizes, but never very large, each imbedded in a little mass of gelatinous matter. The composing units are about 3·5 μ in diameter; it is called *Mycrocystis*. A sample of the water collected had the remains of a number of Entomostraca floating on the surface, but I saw none alive. It was possible to identify the shells of *Bosmina*, and perhaps *Chydorus*, also that of *Cypris*, but the only living representative was the inevitable *Cyclops*, which seemed to be enjoying its usual health and activity.

Rotifera were very numerous and lively, *Brachionus bakeri* and, I think, *B. urceolaris* and a *Philodina*, besides some smaller species were present. *Brachionus* was feeding on the oscillatoria, and it was interesting to watch it get the end of a long (comparatively) filament into its mouth, the end passing down to the mastax, which then worked vigorously at it; reminding one of a rabbit gradually drawing in and eating a grass stem. All of them showed the green of the alga in the mastax, and it was quite evident that the plant was not deleterious in its effect on them, as it is credited with being on fish. It is not easy to represent the refractive bodies in the oscillatoria; they change with the slightest alteration of focus, but Figure 371 shows—highly magnified—some filaments, and a few of the *Microcystis* drawn to the same scale.

JAS. BURTON.

THE CUNEATE MARKINGS OF INSECT SCALES.—Readers of "KNOWLEDGE" are familiar with this subject through the articles and correspondence that have recently appeared in these columns, on the structure of "Podura" scales. The present writer has recently pursued some investigations into the nature of the markings of one of the Lepismidae (*Thermobia domestica*) the results of which have been communicated to the Royal Microscopical Society. A summary of the conclusions arrived at may be of some interest to those who have followed up the subject. In the first place it may be stated that the scales from *Thermobia domestica* are larger than "Podura" scales, and in many respects similar to those of nearly allied species, *viz.*:—*Lepisma saccharina*. The normal scale is somewhat ovate in shape and is traversed longitudinally by striae which are broken up at the margin of the scale into the familiar cuneate "exclamation" markings (see Figure 372). In the case of *Lepisma*

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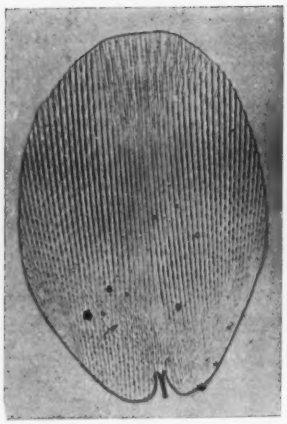

FIGURE 372.
Normal Scale of *Thermobia domestica* × 400.

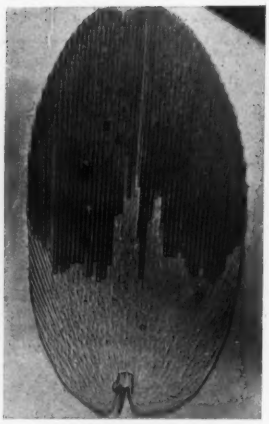

FIGURE 373.
Scale shewing both radial and longitudinal tubes × 400.

saccharina these longitudinal striae were formerly supposed to consist of ribs united by a membrane, but there is no doubt whatever that they are really a series of hollow tubes, the juxtaposition of two neighbouring tube-walls producing the effect of a rib. This is best seen at the pedicle end of the scale, where the tubes are closed by rounded ends. Towards the pedicle, and radiating from the latter, signs of another oblique set of striae may be observed in the normal scale of *T. domestica*. These oblique striae were the apparent cause of the interrupted appearance of the longitudinal striae at the margin of the scale. That these oblique striae really cover the whole of one side of the scale, was proved by mounting the latter in the gummy residue obtained by the distillation of commercial oil of turpentine. This method of mounting shows up the structures of both sides of the scale without optical interference of one set of markings with the other. The marginal cuneate (or "exclamation") markings then disappear, and in some cases, by partial immersion of the scale in the mountant, both sets of striae may be clearly seen (see Figure 373). The so-called secondary markings are apparently caused by two factors: one, minute images formed in the interstices between the two sets of crossing striae, and two, images formed by the actual points of contact of the crossing tubes. By crossing two scales at an angle a complicated system of interrupted markings and secondary structure may be observed (see Figure 374).

In *T. domestica* the oblique striae are next the insect and the longitudinal ones outside. The scale is slightly concave-convex in shape, as if fitted to the curvature of the insect's body, this structure being most marked at the margin where the cuneate markings appear. The latter are mere optical appearances, and are produced by oblique illumination of the two sets of crossing striae or tubes. The oblique illumination is caused by the curvature of the marginal portion of the scale, and is independent of the source or manner of the illuminant to a great extent.

A careful examination of the interrupted markings with the one-tenth inch dry objective, the scales being in optical contact with the cover-glass, shewed that the markings changed their form with exceedingly slight alteration of the focusing. By slow downward focusing, four distinct stages in the evolution of the markings were observed, as represented by the accompanying drawings: 1, connected

FIGURE 375.
First stage in the evolution of the scale markings—"connected beads."

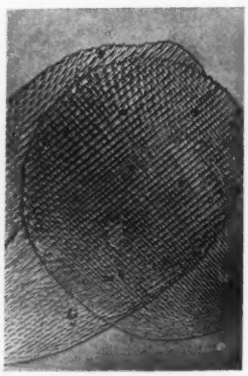

FIGURE 374.
The effect of crossing two scales.

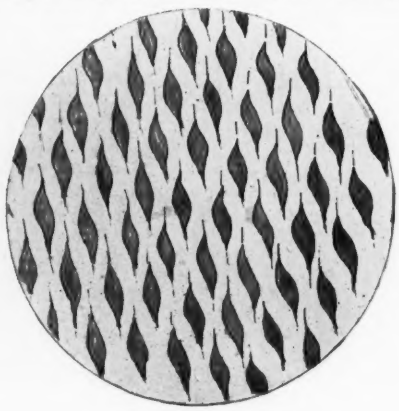

FIGURE 376.
Second stage—"separate elongated beads."

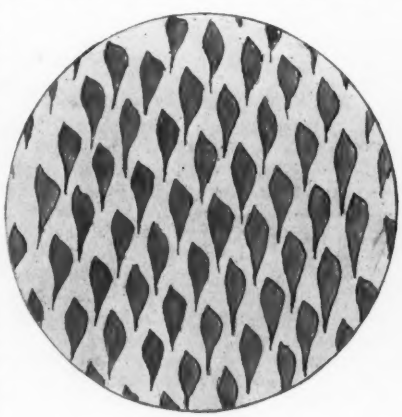

FIGURE 377.
Third stage—"exclamation or clubbed markings."

FIGURE 378.
Fourth stage—"cuneate or wedge-shaped markings."

beads (see Figure 375); 2, separate elongated beads (see Figure 376); 3, exclamation or clubbed markings (see Figure 377); and 4, cuneate or wedge-shaped markings (see Figure 378).

The scales of *T. domestica* appear to contain a highly-refractive oily substance in their composition, and when they are heated and subjected to mechanical pressure air-bubbles may be observed to move along the tubes. Some successful attempts were made to produce the structures of the scale on a large plan by crossing tubes of glass (filled with liquids) at various angles. As a result of these experiments a model, with two revolving sets of tubes in contact, was made, with which, by oblique illumination, cuneate markings were readily produced and photographed (see Figure 379).

JAMES STRACHAN.

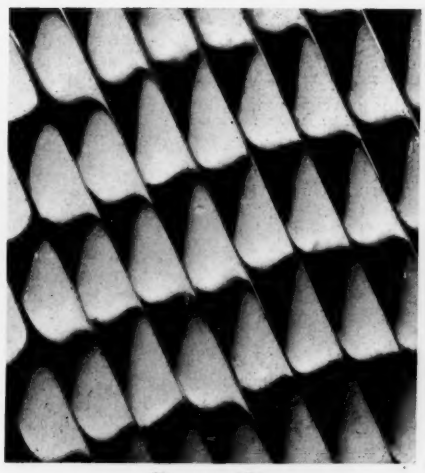

FIGURE 379.

Cuneate markings produced by oblique illumination of a model.

A NEW MICRO-TELESCOPE.—To all those who possess microscopes the knowledge that their instruments may be readily converted into telescopes of high power at small cost will be extremely interesting. The principle of this new invention, which is due to Mr. A. Cornell, of Tonbridge, Kent, resides in the combination with an ordinary mounted microscope of a telescopic objective and the "pin-hole." This combination produces an extremely sharp inverted image in the plane of the microscope stage, the inversion being corrected by the microscope element of the combination.

The attachment for converting a microscope into the telescope shown at Figures 380 and 381 consists of a draw-tube *a* carrying a suitable objective and containing a series of diaphragms for stopping down the light. These diaphragms are so proportioned that the amount of light is maintained through acute angles by concentration; as, for instance, when using an object glass of seven-inch focal length. These graduated diaphragms provide for extremely sharp definition. Although the focal angle is extreme, the *flatness* of field and the wide angle of same are extraordinary. With a telescopic objective of seven-inch focal length and a micro-objective of one-inch focal length a magnification of forty-five diameters is obtained. With such an arrangement Jupiter and four of his moons were observed with astonishing clearness during June. The best general results were, however, obtained with a one and a half inch micro-objective, which so far has given the brightest and most clearly defined image. With this objective the magnification was about twenty-seven diameters.

The attachment is made to fit into the diaphragm or Abbe illuminator rim or under-fitting *d* on the stage or sub-stage. By means of this combination when the telescope attachment is in place any degree of magnification from twenty to forty-eight diameters may be obtained by adjustment of the draw-tube and eyepiece to focus the micro-objective.

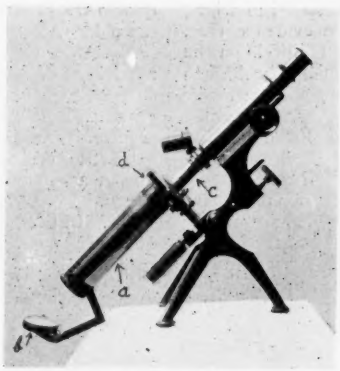

FIGURE 380.

The Micro-Telescope.

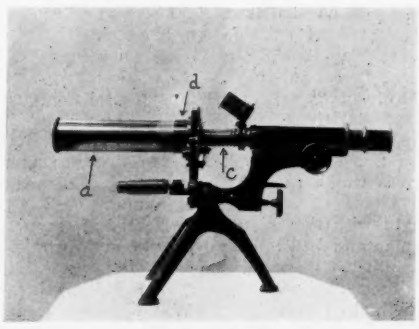

FIGURE 381.

The Micro-Telescope used horizontally.

The only alteration to the microscope which is necessary is to remove the stop screw or bar so as to allow the eyepiece to be lowered below the horizontal to admit of observing objects at an elevation. The ordinary reflector *e* may be removed, or simply turned out of the line of the tube of the attachment *a*. For astronomical purposes and to facilitate observation at high angles, such as the moon or stars at or near the zenith a reflector *b* is attached to the tube *a*. This reflector is ground optically correct for the purpose and is mounted upon a universal joint so as to be adjustable in all directions. By means of this reflector objects overhead or at high angles may be observed with the greatest ease and comfort. When the micro-telescope is employed for terrestrial observation, a tube *c* is employed to screen light from the gap between the stage and the micro-objective. This tube fits on to the micro-objective mount and is readily attached or removed.

The combination forms an exceedingly compact telescope of about fifteen inches in length, and the mechanical adjustments are available for focusing. To further facilitate observation, however, the tripod stand is secured to a special rotatable base mounted on a pedestal or tripod, the rotatable base being movable by means of suitable screw adjustments about vertical and horizontal axes, or two axes perpendicular to each other but inclined to the vertical or horizontal. Provision is thus made for keeping an object in the field of the telescope when it is being employed for astronomical purposes.

ROYAL MICROSCOPICAL SOCIETY.—June 19th, 1912. H. G. Plimmer, Esq., F.R.S., President, in the Chair.—A paper by Lord Avebury was read, giving a short account of the development of pollen and of recent researches on fertilization which shows more and more complexity. He divided pollen into:—

(1) Aërial pollen carried by the wind. This was probably the original form, and was dry, spherical and smooth.

(2) Aërial pollen carried by insects, which as a rule was elliptical, but often spherical, in which case it was generally spiny.

(3) Sub-aqueous pollen, often elongated and filiform.

The forms of pollen are very various—barrel-shaped, square, facetted, dumb-bell shaped and many abnormal and peculiar types. He then alluded to the distribution of these forms in the different orders; in some of which the pollen is more or less uniform, while in others there are differences even in the same species.

The general colour of pollen is yellow, but it is sometimes orange, violet, blue, purple or white.

Perhaps the most remarkable case is that of the loosestrife (*Lythrum salicaria*) in which the pollen of the short stamens

is yellow; while that of the long ones is bluish-green. In some cases the grains of pollen have numerous threads, probably of mucilage—formed from the outer wall.

As already mentioned, by far the most common form of pollen is elliptical, with three ribs. For this no explanation, he believed, has yet been suggested. Such pollen was originally spherical, and only assumed the elliptical three-ribbed form after leaving the anthers and losing a certain amount of moisture by desiccation. Fairbairn in his "Useful Information for Engineers" describes how tubes give way under pressure. They collapse at three equi-distant points, thus assuming a three-lobed form. Lord Avebury suggested that the three-lobed form of most pollen was perhaps due to the same cause, and did not present any advantage in itself. At the same time the extine was in many cases thinner in the furrows. This, he thought, was perhaps explainable as being due to inheritance. He suggested that the dumb-bell form was due to the fact of the furrows being shorter and deeper in the middle.

It was interesting to compare the form of the pollen when the order contained both anemophilous and entomophilous species. For instance, Compositae for the most part have spiny pollen and are entomophilous, but the Edelweiss and some allied species are anemophilous and smooth. The Rosaceae are almost all entomophilous, with elliptical pollen, but *Poterium* is anemophilous with spherical pollen. A good case is afforded by the Salicaceae; the willow is entomophilous, with elliptic three-ribbed pollen. The Poplars, on the contrary, are anemophilous with spherical pollen.

He then discussed the size of pollen, and referred to a long table which he thought afforded conclusive evidence that, though the size of the pollen did not depend entirely on the pistil, and the length, therefore, which the pollen tube had to traverse, still as a general rule, the longer the pistil the larger the pollen. The genus *Mirabilis* affords a very interesting illustration. It had been long ago noticed by Kolreuter that *M. jalapa* can be fertilized by the pollen of *M. longifolia*, but that *M. longifolia* cannot be fertilized by *M. jalapa*.

No explanation of this curious fact had, so far as he knew, hitherto been suggested. He submitted that it was probably due to the relative size of the pollen and length of the pistil—the pollen of *M. longifolia* being considerably larger than that of *M. jalapa*; so that the pollen tube of *M. longifolia* can reach the pistil of both species, while that of *M. jalapa*, though large enough for the pistil of its own species, is unable to reach those of *M. longifolia*. He concluded his memoir with a description of the pollen in the principal British orders.

A paper "On Some New Astrorhizidae and their Structure" was contributed by Messrs. E. Heron-Allen and Arthur Earland. Two new species of *Psammosphaera* and one of *Marsipella* were described from specimens dredged by Mr. Earland in the North Sea in connection with the work of the International North Sea Investigations (Scotland).

In *Psammosphaera rustica* the rhizopod constructs a polyhedral test of spicular fragments selected of suitable length and cemented side by side in a single layer, while in *Psammosphaera Bowmani* large flakes of mica are selected, and cemented together at the edges so as to form a polyhedral test. *Marsipella spiralis* constructs a straight tube of minute spicular fragments of approximately equal length, which are embedded, side by side, in a fine grey cement. The spicules are arranged in definite rows which run in a sinistral spiral round the tube.

The authors also dealt at some length with the minute structure of *Technitella legumen* Norman and *Marsipella cylindrica* Brady and described some hitherto unrecorded details of the construction of the tests in these species.

Dr. J. F. Gaskell communicated "A method of embedding tissues in Gelatin." The tissue is fixed in a formalin mixture; previous to embedding all formalin must be removed by washing in running water twelve to twenty-four hours. The gelatin is soaked for three to four minutes in cold water, then drained and melted, and the tissue is immersed in this for two to five hours in an incubator at 37° C. It is then cast in paper boxes in this gelatin and allowed to set at room temperature; when cool, it is put into a formalin vapour chamber to harden. The hardening is not satisfactory in a less period than three days, and may be continued indefinitely till the block is wanted.

Sections are cut by the freezing method, the block being pared down and attached to the stage of Aschoff's CO_2 freezing microtome by means of a drop of gum solution.

Sections can be obtained of any tissue 10μ thick and of most tissues hitherto tried 5μ sections are obtainable.

QUEKETT MICROSCOPICAL CLUB.—On June 25th, 1912, Mr. W. B. Stokes (the honorary secretary) read a paper on "Resolutions obtained with dark-ground illumination and their relation to the 'spectrum' theory." Serious students of microscopical images have long sought a crucial experiment which shall decide the claims of the two theories, those of Airy and Abbe, which have been put forward to explain them. The image obtained by dark-ground illumination offers the very example sought. If the Abbe spectrum theory is to be applied, it will be necessary for maximum resolution that a spectrum of the second order be included in the objective to coöperate with that of the first order, each spectrum just entering the objective on opposite sides. It was then shown, using the usual formula, that an objective of N. A. 1·0 and illuminator of N.A. 1·35 would resolve 58,750 lines per inch at λ 5080. It was found, however, in practice, that an objective of N.A. 0·86 with illuminator of N.A. 1·35 would resolve the 60,000 band of a Grayson ruling, and also the Cherryfield *Navicula rhomboides*, believed to have rows of perforations 60,000 to the inch. These results and others quoted would seem to show that we are justified in turning to the older (Airy) theory for guidance.

Mr. A. E. Conrady, F.R.A.S., said the formula quoted for resolving limit applied to a grating absolutely uniform in ruling and one which had also an infinite number of lines. When a grating has a limited number of lines it becomes easier to resolve. Grayson's thirty lines at sixty thousand is in this way subject to a discount of about three per cent. The coarsest line in a group of rulings will influence the resolution of that group.

Mr. R. W. H. Row, B.Sc., reported the occurrence, at Malden railway station, Surrey, and showed specimens, of a rare saw-fly, *Phyllotoma* (*aneris*?).

ORNITHOLOGY.

THE GREAT REED WARBLER.—Mr. E. C. Taylor writes from Yarmouth as follows:—"Your Ornithological readers may be interested to learn that the Great Reed (or Sedge) Warbler (*Acrocephalus turdoïdes*) was seen by me on Sunday last between Horning Ferry and Ranworth. I should consider that the bird being here at this time of the year makes it very probable that it has been breeding here.

I was on an entomological hunt by the side of a reed bed near a small "corr" when my attention was drawn by a bird of unusual size flying in and out of the reeds. It settled on the stem of a reed quite near me and I had a good view of it for quite thirty seconds and am certain of its identity."

"BRITISH BIRDS."—In the August number of *British Birds* there are as usual a number of very interesting notes. Mr. P. F. Bunyard records some of the earliest nests which he found in 1912. He thinks that May 1st for the Blackcap in Kent, and May 4th for the Lesser Whitethroat in Surrey may be new records. Mr. Jourdain, in an editorial note, however, gives April 28th for the latter bird on the authority of Mr. J. E. Harting, who states that an egg was found in Willesden on that date. Mr. Bunyard also found a Cuckoo's egg in Kent on May 6th, which is a fortnight earlier than any of his own previous records. A second specimen of the Isabelline Wheatear, Mr. Thomas Parkin records, has been shot in Sussex, which is apparently only the fourth specimen obtained in this country. It has been secured by Mr. W. H. Mullens, who has presented it to the Hastings Museum as an addition to the fine collection of local birds already given by him to that institution.

XUM

PHOTOGRAPHY.

By EDGAR SENIOR.

PHOTO-MICROGRAPHY WITH MEDIUM POWERS.—In dealing with the subject of low power photo-micrography in the June number of "KNOWLEDGE" we explained that the size of the images produced was the result of considerable camera extension "one hundred and sixty-three centimetres," and in the last issue of the journal it was shown how the magnification could be still further augmented, by the use of an eyepiece "ocular" although at the expense of very considerable restriction of the field. If the two illustrations, photo-micrographs of the proboscis of a blow fly, one magnified eighty diameters and the other "a portion" three hundred and twenty diameters, be carefully examined, we fail to find any difference in the amount of detail present in either. The question, therefore, naturally arises as to what is the use of this extra and great amplification; what does it do? and is it necessary or desirable? To answer this question several things have to be taken into consideration, such as the resolving power of the objective, and the magnification that may be necessary in order that the eye may be able to clearly discern the structure resolved. As the primary use of a microscope is to enable the observer to see distinctly the minutest details in the image of the object under observation, a degree of enlargement that will ensure this would appear to be all that is necessary, unless from individual requirements or photographic purposes it be desired to go beyond it. In order to arrive at the conditions requisite to get the most out of our instrument, we must first of all consider the objective, with regard to its ability to resolve fine structure. Now it is well known that the resolving power of any lens depends upon its aperture, and that of the one inch objective employed in photographing the images of the proboscis was found to be ·2 N.A., and this theoretically should possess a resolving power for the brightest part of the spectrum visually of nineteen thousand. In other words, the lens should be able to separate lines or structures as close together as the one nineteen-thousandth of an inch. It only remains then to magnify the image sufficiently that the eye may be able to see the details readily when viewed under proper conditions. It is generally considered that the normal eye is able to distinguish lines as close together as the one two hundred and fiftieth of an inch when viewed at a distance of ten inches from it. So that in order to take full advantage of the resolving power of our lens we should have to enlarge the image seventy-six times, in this case, to fulfil the required conditions. As the magnification was eighty diameters nothing further should be gained by increasing it, unless, of course, it were found not sufficient in individual cases. It has been stated that the limit for best definition is reached by employing as the degree of magnification "in diameters," the value obtained by multiplying the N.A. of the objective by four hundred. So that in the above case in which the N.A. = ·2 we should get 400× ·2 = 80 diameters, and any further increase beyond this would result in an inferior image. In considering, then, the question of photo-micrography with medium powers, it is not so much the increase in the initial magnifying power of the objective that concerns us, as the gain due to their larger aperture. As an example we may take the illustration to this article, which was photographed with a Zeiss sixteen millimetre apochromat with a four-inch projection ocular. As far as size of image is concerned, this could have been obtained by using a higher eyepiece with the lower power, but the sixteen millimetre has an aperture of ·3 N.A. as against ·2 N.A. in the former case, which means that the resolving power is half as much again with the sixteen millimetre lens compared with that of the twenty-four millimetre one. We thus see that the aperture is the all-important consideration; that mere magnification beyond the degree necessary for observation becomes useless, but as the initial size of the image increases the higher the power of the objective, a lower eyepiece can be employed with advantage. The illustration (Figure 382), taken with a Zeiss sixteen millimetre apochromatic objective and a four-inch projection ocular, was magnified four hundred diameters. The negative was made on an Imperial N. F. plate of a speed of two hundred and twenty-five H. and D. An exposure of ten seconds was given, using a deep orange screen, the specimen being stained blue. The image was developed as before with pyro and soda.

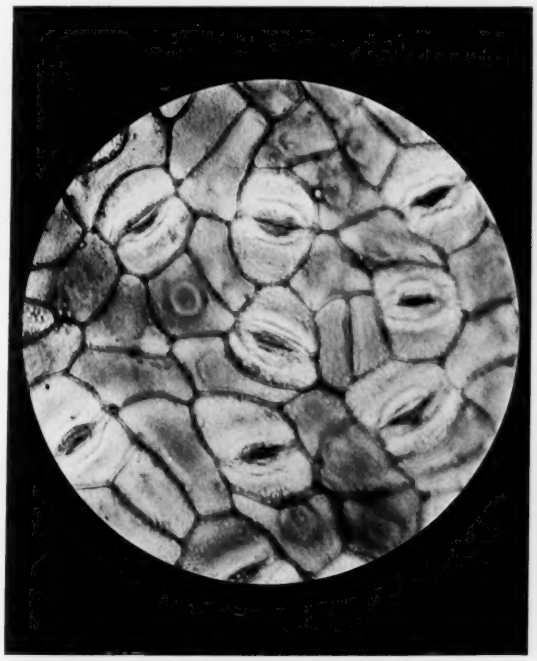

FIGURE 382.

Stomata in Cuticle of Mistletoe × 200 diameters.

Photographed with a Zeiss 16 mm. Apochromatic Objective and a four-inch Projection Ocular.

EXPOSURE TABLE FOR SEPTEMBER.—The calculations are made with the actinograph for plates of speed two hundred H. and D., the subject a near one, the lens aperture F. 16.

Day of the Month.	Condition of the Light.	Time of Day.		
		10 a.m. and 2 p.m.	9 a.m. and 3 p.m.	7 a.m. & 5 p.m.
Sept. 1st	Bright	·12 sec.	·14 sec.	·28 sec.
,, ,,	Dull	·24 ,,	·28 ,,	·57 ,,
Sept. 15th	Bright	·13 sec.	·15 sec.	·35 sec.
,, ,,	Dull	·27 ,,	·3 ,,	·7 ,,
Sept. 30th	Bright	·15 sec.	·19 sec.	·63 sec.
,, ,,	Dull	·3 ,,	·39 ,,	1·26 ,,

Remarks.—If the subject be a general open landscape, take half the exposures given here.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

FORMATION OF HABITS.—One of the most interesting kinds of modern work in natural history is the study of habit-forming. Mr. Asa A. Schaeffer has been recently experimenting with frogs in this connection. Individuals of three different

species, *Rana clamata*, *R. sylvatica* and *R. virescens* learned to avoid disagreeable objects, such as hairy caterpillars, in from four to seven trials, and the habits persisted for at least ten days. A *Rana clamata* learned in two trials to avoid earthworms treated with chemicals, but the "habit" persisted perfected for only a short time. When the hairy caterpillars were avoided, active muscular rejection of the caterpillar accompanied each trial; but in the trials of the chemically treated earthworms, no rejection, nor any muscular action other than active swallowing of the food, was observed. "The latter habit was formed entirely within nervous tissue." "The rapid formation of habits and the peculiar process of examination observed while the habits were formed, indicate intelligence of a relatively high order."

HEARING IN FISHES.—Using the term "sounds" to include any vibrations of the water, it may be said that sounds affect fishes through three sets of sense-organs—the skin, the lateral-line organs, and the ears. Professor G. H. Parker has made some interesting experiments and observations, particularly as to the effects of explosive sounds, such as those produced by motor boats and guns.

It has been shown within recent years that a fish can feel sounds through its skin in much the same way as a man can feel the vibrations of a musical instrument when his hand is in contact with it. It has also been shown that some fishes are aware by means of their lateral-line system of relatively low vibrations, such as trembling movements of the water. Thirdly, Professor Parker has convinced himself that the internal ear is also an organ of hearing. This may seem a gratuitous thing to prove, but only to those who are unaware that there are many ears which are not hearing ears. The ears of fishes have to do with the adjustment of bodily motions and equilibrium.

"The sounds produced by motor boats are extremely faint under water, and have little influence on the movements and feeding of fishes. Such influence as they do have is temporary, and very much restricted in local extent. Single explosive sounds, like the report of a gun, may startle fishes and cause them to cease feeding, but these responses are also temporary and local. Although most sounds are repellent to fishes, some may serve as lures to particular species." Fishes like the Drumfish and the "Squeteague" produce noises which are, without much doubt, concerned with bringing the sexes together at the breeding season.

LOCOMOTION OF SEA-URCHIN.—Some thirty years ago Romanes and Ewart pointed out that a sea-urchin uses its lantern in progression out of water, and gave an account of the manner in which the lantern acts. But this seems to have been lost sight of. In 1910, Miss Abel, a student attending one of the nature study classes at Millport Marine Station, noticed that the sea-urchin given her to observe seemed to move by lurches occurring at intervals, and that just prior to each lurch the whole urchin rose up slightly from the surface of the table. This observation was the starting-point of a careful investigation by Dr. J. F. Gemmill into the locomotor functions of Aristotle's lantern.

"When travelling actively (out of water) the urchin raises itself from time to time on the tips of its teeth in preparation for a forward "step." The step is then accomplished by means of (a) strong pushing or poling on the part of the lantern; (b) similar but usually weaker action on the part of the spines; (c) the influence of gravity acting at a certain stage. After each "step" the lantern is retracted and swings forward, so that the teeth come into position for initiating a new "step."

Under water the lantern is not needed for ordinary locomotion, particularly over more or less horizontal surfaces. The tube-feet and the spines are the effective agents. But it will help if the urchins are loaded, or travelling up a slope on certain surfaces, or only partially immersed, or mounting rapidly up a vertical surface.

"The locomotor action of the lantern in urchins is a particular manifestation of a rhythmic functional activity which can also subserve feeding (no doubt the chief function), boring, and forced respiration. In addition it possibly aids the swallowing of food, the evacuation of faeces, and the maintenance of physiological turgescence in various internal cavities." Filling of the gills takes place during retraction of the lantern and emptying during protrusion.

MECHANISM OF RESPIRATION IN INSECTS.—When we watch a drone-fly, for instance, seated in the sunshine in the middle of a dandelion inflorescence, we notice panting movements of the abdomen,—the expiratory movements; for recent research, like that of Johann Regen's, fully confirms the old conclusion of Ratke and others—that expiration in insects is the active process and is mainly due to the contraction of abdominal muscles. The abdomen expands again because of its elasticity and the air enters the tracheae passively. It is an interesting instance of analogy that in insects and in birds we should find the same peculiarity of active expiration and passive inspiration,—so different from what we are familiar with in our own body.

COLOUR CHANGE IN SALAMANDER.—It has been proved by Kammerer and others that the Spotted Salamander (*Salamandra maculosa*) becomes almost black when the soil of its vivarium is dark and relatively dry. Two things happen: the yellow areas become gradually smaller, retreating towards the centre until they disappear; and the dark areas become darker. Experiments following the ordinary method of exclusion, *e.g.*, using a black-paper ground with normal humidity, show that the shrinkage of the yellow spots is affected by the colour of the ground, and the darkening by increasing drought. Alois Gaisch relates in corroboration of Kammerer's experiments that he put a salamander into a vivarium with black peaty soil which remained moist, and found it almost unrecognisable after three months. He gave it a good bath, but it remained very dark. The yellow spots had become much smaller and there were many black dots about their margins. Microscopic examination showed that black pigment had abundantly invaded the yellow areas. An interesting fact, noted by Gaisch, is that two other salamanders put in about the same time showed no change of colour, which seems to show that there are differences in individual susceptibility, perhaps in age-susceptibility.

AMPHIBIANS OF THE GREAT COAL SWAMPS.—The ancient forest-swamps of the Coal Era have meant much to man, and their exploration has a unique interest. Mr. W. D. Matthew, of the American Museum of Natural History has been telling us lately about *Eryops*, a primitive Amphibian which lived about the close of the Carboniferous Period—"five times as old as *Eohippus*, a hundred times as old as the mammoth or mastodon or the earliest known remains of man." It was "a sort of gigantic tadpole or mud puppy, with wide flat head, no neck, a thick heavy body, short legs and paddle-like feet and a heavy flattened tail." Heavy and clumsy, small-brained and slow, it was near the top of the genealogical tree in its day! "The giant dragon fly that darted over the head of the slow-crawling *Eryops* might seem, except in size, a far superior type of being, a far more promising candidate for the position of ancestor to the intelligent life which was to appear in the dim future." But it had reached the limit of great organisational change, while "the amphibian was but beginning the adaptation of the vertebrate structure to a terrestrial life." Perhaps the possession of an internal instead of an external skeleton was, as Professor Shaler suggested, an important feature in giving free play to evolutionary potency which lay concealed in these unpromising amphibians of the carboniferous swamps.

HOW DOES A YOUNG BIRD BREAK THE EGG-SHELL?—The answer that rises to the lips is "By means of its egg-tooth." But the bill and its egg-tooth are only the instruments, what about the musculature? Franz Keibel has inquired into this in the case of the chick and the duckling. He finds that it is the musculus complexus that is actively concerned, and that it is very markedly hypertrophied for some time before hatching. On the tenth day after hatching it shows no peculiarity.

SENSE TRAINING.

By JOHN B. HUBER, A.M., M.D.

To one ambitious of leading the scientific life, sense training is from the beginning most essential. "Seeing is believing," but the belief thus founded may not be rational. Seeing, reviewed and if necessary revised by the reasoning faculty, will then be soundly based. Only from such process can facts be born—facts, the only building material with which science can work. The senses are by no means a sure guide; the very best they can do is to appreciate phenomena: that is, appearances. The stick appears broken in the pail of water; reason assures that it is not. Using a bright spoon for a mirror, one appears variously, as he holds the spoon inside or outside, or up and down, or sideways; but it is to be hoped one does not look any of those ways in reality. Cross the middle over the index finger; roll their tops over a bread pellet in the palm of the other hand, and the sense of touch will convey the impression of two pellets; but reason corrects the impression, and convinces us there is but one. Reason must ever bring judgment, memory and experience to bear upon the perceptions which the senses convey to the cerebrum; by these means reason must constantly be rectifying false sense.

It is amazing how frequently the imagination plays fast and loose with the sense functions; delusions, illusions and hallucinations being the result. Le Bon, in his fascinating book "The Crowd, A Study of the Popular Mind," tells of a crew shipwrecked upon a raft, who kept eagerly scanning the horizon for a sail. After some days of watching one of these poor men, his psychism perturbed by his sufferings, being obsessed through desiring to see a rescuing ship, unquestionably saw something; and so desperate was the hope of his companions, that one and all agreed with him that the thing he pointed out was a vessel which could rescue them. When they came upon it, however, they found it but a tree which had evidently been uprooted and had gone adrift in an equatorial storm. Tuke, in his admirable book "The Influence of the Mind on the Body," relates how a boy who had on an afternoon seen a hanging, which had naturally much affected him, took a stroll along a country road in the evening of that dreadful day. He presently saw projected against the moon-lit sky the gibbet of the afternoon, and the criminal suspended from it. He ran home dreadfully frightened, to find that a cord dangling over the brim of his hat had by his overwrought imagination been metamorphosed into the aërial gallows.

Every reader will recall how he has in like manner been tricked by his senses. Hundreds of instances might be cited of delusions entertained by the unscientific, the unsophisticated, the highly emotional; people in whom such aberrations are not without excuse. We who pride ourselves upon our attainments in science are so prone to consider such delusions the exclusive property of geniuses, spiritualists, theosophists and other people whose imaginations tend to work overtime, that we feel distinctly humiliated to learn how men even eminent in science have been the victims of psychic perturbations: as for instance, when the telephone was invented, a lecturer who was giving a public exhibition of the apparatus clearly and repeatedly heard the notes of a trumpet which he had arranged to be played at the other end. He declared that he heard; nor need the record be doubted. Yet none of his audience could hear the trumpet; and for the all-sufficient reason that the trumpeter had made a mistake in the day, and was not in his place at all.

A very modern instance of "illusion caused by a species of auto-suggestion based on preconcerted ideas," is furnished by the episode of the N-rays, which all competent men now agree never had any existence at all. Professor Blondlot believed (in good faith, of course), that he discovered these rays at Nancy in 1903. He described them before the French Academy of Sciences, which body gave him a gold medal for his discovery.

Up to 1906, there were published one hundred and seventy-six original papers concerning these rays. Blondlot's observations were in turn confirmed by such well-known physicists as Charpentier and Becquerel. The N-rays were considered to be given off by almost all substances when in a state of strain; a tempered steel bar, Nernst lamp, and even a human nerve and muscle would emit them. The rather fanciful suggestion was advanced that if a certain radiation were given off by our bodies, according to their degree of activity, our thoughts might possibly be photographed: "thoughts being only brain rays." (Of course, the work within the last year of Drs. Kilner and Fielkin in London, as to the photographing of the "atmosphere" or the "aura" which the human body is considered to exhale, springs at once to mind.)

The N-rays, stated French investigators, could be reduced or removed by anaesthetics; a tempered steel bar, for that matter, could be chloroformed into quiescence. Following upon this the invitation came naturally enough to men of science "to revise some of our notions on the difference between the organic and the inorganic." The N-rays were held to be even more wonderful than the X-rays or radium. Oddly enough, however, the N-rays did not, like the X-rays, affect either the spectroscope or photographic plates. Admittedly they were rather baffling and elusive, at least to those inexperienced in detecting them; but they had one physical effect upon which experimenters relied—their power to intensify a light. A marked increase of luminosity was considered to be perceptible when an N-ray was directed upon a spark; or if a bar of tempered steel were held near a clock in a dark room, it was supposed to be possible to read the time.

As the months rolled by Blondlot's experiments were confirmed, and were even extended outside France. Yet many scientific men utterly failed from the first to observe any of the phenomena described. English and German investigators became particularly sceptical; and rather absurdly a dispute arose which, by the law of the crescendo in psychology, accrued progressively as to bitterness; compliments increased in warmth as they lost in polish. Things became quite akin to that immortal "Row upon the Stanislaus." Two camps were formed—the Latin and the Teutonic. The French imputed racial prejudice and animosity to their foreign critics. It was suggested that the rays could be distinguished only by the more sensitive and finer-fibred brain of the Latin; whilst what, *sacre bleu!* could be expected of the fog-muddled British brain, or of the beer-befuddled German psychism! The matter in dispute threatened to place itself beyond the bounds of any reasonable demonstration. Presently, however, the coolest French scientific men gradually came to suspect that if no results could really be obtained in England or Germany, the explanation of the French experiments must be subjective and psychological rather than objective and physical.

Finally, the *Revue Scientifique* settled the question in a very simple way. It was proposed that several boxes of exactly similar appearance, some containing pieces of lead, others of tempered steel, should be sealed; and Blondlot or his assistants were to decide which of the boxes contained the active material. Blondlot refused this test, saying that "the phenomena were far too delicate for such a trial"; and he left "everyone to his own opinion on the N-rays, either from his own experiments, or from his confidence in others." Thus was the dispute transferred from the realm of fact to that of opinion, experimentation ceased, and so far as science is concerned the incident was closed.

Such incidents as these are rather humiliating to the scientific temperament, which, nowadays, is just a trifle inclined to self-satisfaction. Fortunately, they are extremely rare. Science is knowing; good science is ever certainty grounded upon demonstration. To this end the pre-requisite is the trained senses. Science's votaries, moreover, if they are to serve her well, must ever be free of auto-suggestions and haphazard conjectures incapable of verification.

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FURTHER REMARKS ON THE TRUE STRUCTURE OF THE DIATOM VALVE.

By T. F. SMITH.

A CHANCE discovery, often the only one fortunate chance of a lifetime, has enabled the writer to push our definite knowledge of diatom structure still some steps onward from the point reached in his last article. Trusting that the results here shown will prove of both interest and value, he now begs to lay them before the readers of "KNOWLEDGE." He wishes also that this article should serve a twofold purpose; the second as illustrating what can be done by high-power work in photomicrography with cheap lenses. The illustrations for the last article were all produced by expensive apochromatic objectives. For the present one, only the ordinary achromatics were used. Most of the negatives reproduced here were taken with his own lenses—a dry one-sixth inch of 0·85 N.A. (only one with this), and an oil-immersion one-twelfth-inch of 1·30 N.A., both by Swift & Son. For the others he is indebted to the firm of Mr. Charles Baker, of Holborn, who kindly placed one of their one-twelfth inch oil-immersions of the same aperture at his disposal. The figures may be allowed to speak for themselves, though it may be pointed out that the apochromatic used on the previous occasion had an aperture of 1·40 N.A. and was besides the finest of its class; while the achromatics used to illustrate the present article were limited each to 1·30. To say nothing of apochromatism, this difference upon many objects may not mean much. When, however, optically separating closely connected structure the extra ten points tell.

One thinks it necessary for the benefit of others to call attention to these matters. It has been, indeed, the habit of some writers to throw cold water upon the employment of the ordinary lenses for photography in high power work. In the language of one: "That while with low powers, when used in conjunction with suitable screens, excellent pictures can be produced . . . with high powers this is not the case, and those who desire to obtain the very finest results possible by the aid of photography, should certainly obtain the services of the apochromat rather than of its cheaper rival." Indeed, in an annual of microscopy, the same writer has produced two plates, to show by contrast the difference of appearance between the same object, when photographed by the apochromatic and the ordinary achromatic objectives. Yet he admits in his last book that it is often difficult to tell at first the difference visually between the two, as the present cheap lenses are made.

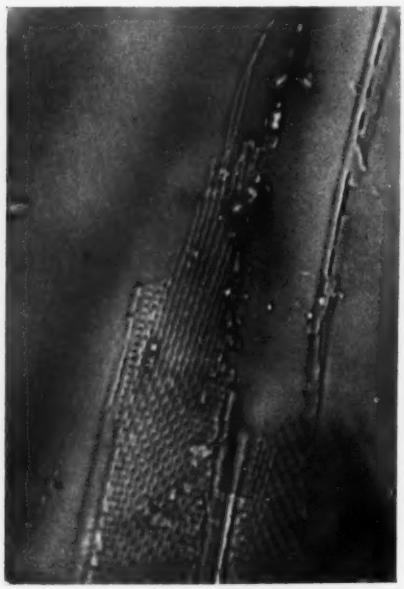

FIGURE 383.

Pleurosigma formosum, showing torn fibrils projecting over the empty space where part of the under layer has sunk to the slip. Magnified one thousand six hundred diameters.

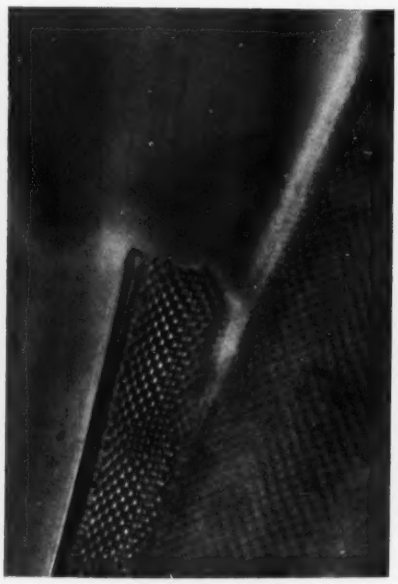

FIGURE 384.

The under layer of the same valve, showing where the sunken part has broken off.

Now this present writer will admit that after reading the words, "the very finest results possible," it was with fear and trembling he approached the task of high power work with the cheaper rival. Yet after all, there is no magic required in photomicrography. He has always maintained that the common objective will produce as good an image in a photograph as it does visually. The image upon the screen, whether good or bad, is really the thing. After, it is the same process as in ordinary photography. Of course, one is aware that in many lenses there is a want of coincidence between the chemical and the visual foci. The use of orthochromatic plates in nearly every instance will correct this discrepancy, and the same kind of plate, used with a suitable screen, will correct the remainder. An ordinary achromatic with a red correction will work upon any kind of plate.

An eminent authority in microscopy confirms this opinion. Mr. E. M. Nelson, in one

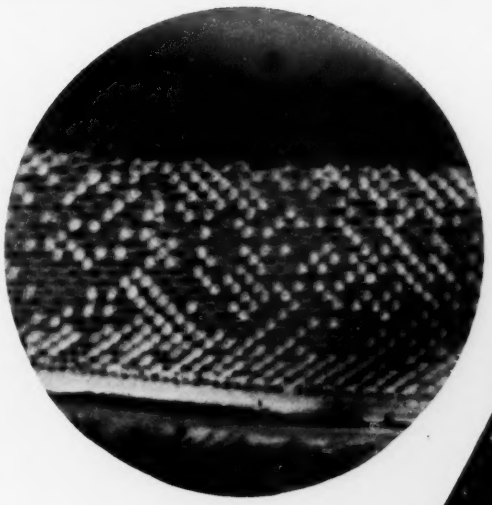

FIGURE 385. *P. formosum*, showing patches of little white discs amongst the fibrils, × 2000.

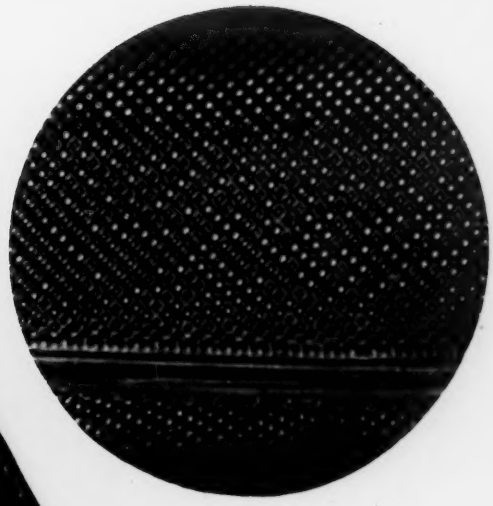

FIGURE 386. The layer underneath, showing the cause of the patches above.

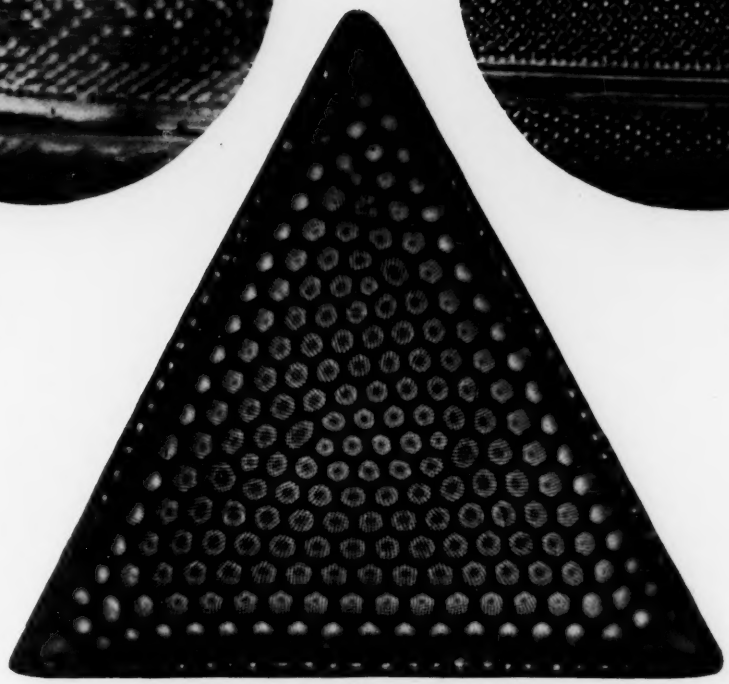

FIGURE 387. *Triceratium favus*, side view. Objective used, Swift & Son's one-sixth inch, dry of 0·85 N.A., orthochromatic plate, no screen, magnification six hundred diameters, exposure by lamplight ten minutes.

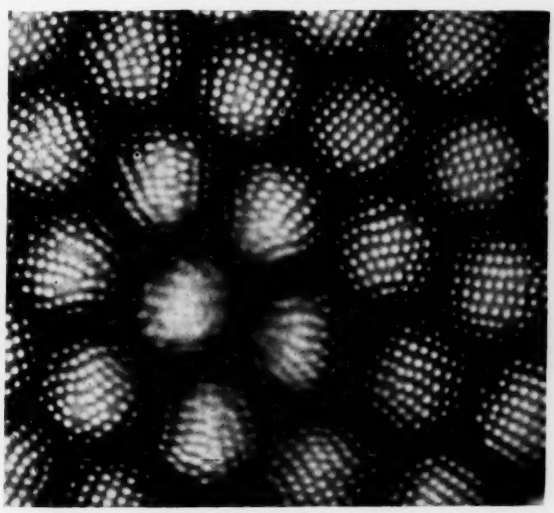

FIGURE 388. Part of the same valve × 2500. Objective used, Swift & Son's oil immersion one-twelfth inch of 1·30 N.A.

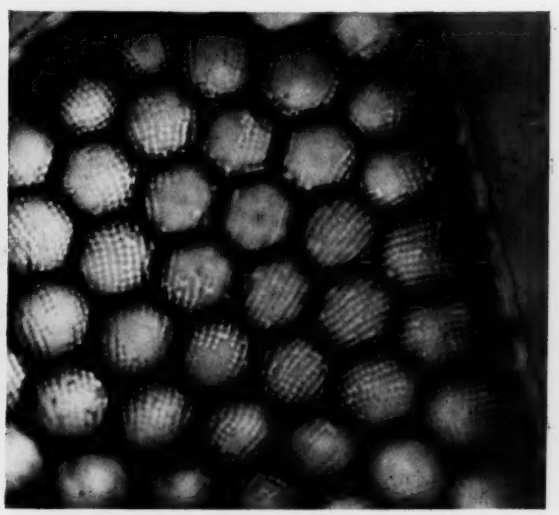

FIGURE 389. *T. favus* from another valve, showing torn structure. Magnified one thousand five hundred diameters.

of his addresses as president of the Quekett Club, when speaking of screens used in connection with objectives, says :—" They are of special service with cheap lenses (*i.e.*, semi-apochromats), because they remove the secondary spectrum, making the lens as efficient as an apochromat. So remarkably is this the case that with equal apertures it is impossible to say whether the objective on the nosepiece is an expensive apochromat or a cheap semi-apochromat. In photomicrography not only are the preceding remarks applicable, but also colours difficult to photograph are rendered neutral."

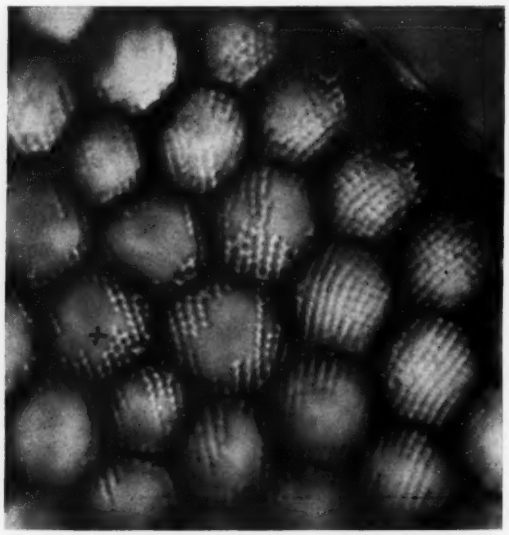

FIGURE 390. *T. favus*, same valve, to illustrate the forming of pseudo-hexagons, black dot. Magnified two thousand five hundred diameters.

The photomicrographs obtained with the Swift oil immersion to illustrate the present article, were taken in conjunction with a yellow screen upon colour correct plates; those with the Baker objective upon ordinary plates, some without a screen and the others in connection with a pot green screen, cutting off the red. This screen undoubtedly increases the resolving power of the lens, besides producing a beautiful image. In photographing with lamp-light, however, it has the disadvantage that the exposure must be prolonged for at least fifteen times beyond that required without a screen. The average exposures with no screen, ranged from ten to fifteen minutes, with a yellow screen, from a quarter to half-an-hour, and with the green screen, three hours. Unfortunately this is not the worst; the chances are that after the three hours one will find the focus shifted, and the image useless. With a camera upon a common kitchen table, over which each end projects at least a foot; with the table upon a floor with wooden joists; when it is sought to use a magnification of 2750 diameters the conditions are not conducive to too much stability.

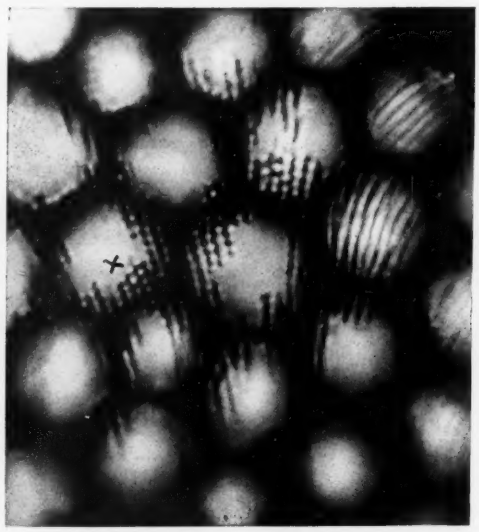

FIGURE 391. *T. favus*, from the same spot, to show the white dot. Magnification the same.

The first part of the present article, now that we are come to the subject, is rather an attempt at meeting objections, of further amplications of the last, than of raising new points. As to the first there is always a doubt in many minds as to the reality of structure when one is said to be superposed upon another; Mr. F. J. W. Plaskitt, to wit, who speaks of the fibrils in *Pleurosigma* as being kaleidoscopic. One wishes he had given the chance to reply to his strictures; yet, like the small boy in *Punch*, who chalked up "No Popery," and then ran away, he finds it more prudent to retire from the contest. Figure 383 of this article, however, should settle the point. In a broken valve of *Pleurosigma formosum* the fibrils are seen projecting forward into space, the corresponding part underneath being wanting, or rather having sunk to the bottom against the slip. The fracture where it has broken off is shown in Figure 384, taken at a lower focus.

In Figures 3 and 3A of the first article, there is shown in one the normal appearance of the outer side of the valve and, in the other, the second layer immediately underneath. Figure 9 of the same article shows the fibrils causing the appearance naked, as it were; but the letterpress assigns no reason beyond saying that the valve had been acted upon in some way. This lack of information, one thinks, can now be supplied in the Figures 385 and 386 of the present article. Of course, it is understood that the description can only apply to a valve mounted dry; when mounted in a medium all such fine distinctions are obliterated. In Figure 385 the fibrils are seen placed lengthways upon the valve, but at intervals there are collections of bright discs of light entangled amongst the meshes. Underneath, in Figure 386, is found the cause. The under surface is occupied by an apparent sieve-like structure; but instead of being regular in size, many are much larger, and in the grouping correspond to the focal points of light in Figure 385. The explanation seems to be this. Only the larger apertures underneath appear to be capable of acting

as lenses of long enough focus to form an image in the grating above. The others stop short, either form no image or weaker ones represented by the apparent rings. In only a few instances, however, are these irregularities of structure seen, and not often is there an appearance of rings, even when not otherwise filled. The spread slide from which the photographs were taken contains hundreds of forms, but only in some half-dozen are those variations apparent. The rest, on the outer side, look as in Figure 387, referred to above. Yet the few exceptions supply the key to the structure of the *Pleurosigma* valve.

The loan of a spread slide by a friend has supplied the writer with the materials for the greater part of the rest of his article, *Triceratium favus* there being one of the leading features; upon one of the specimens, and others after that, he stumbled upon what he thinks is a surprising discovery. The surprise also is that no one had ever made it before. He has started enquiries and satisfied himself that the knowledge up to now remained as his own sole possession. Yet no other genus of diatoms has been so much written about. *Triceratium*, like other families of distinction, possesses a history, and was one of the first of the kind to find a historian. It was also the earliest upon which was discovered what is now known as secondary structure.

The genesis of this family is first recorded by Mr. Brightwell, F.L.S., in the July number of *The Quarterly Journal of Microscopical Science* for 1853, the title, "On the Genus *Triceratium*, with Description and Figures of the Species." In the beginning of the article he says: "The genus *Triceratium*, with several other species, was established by Ehrenberg in a memoir communicated by him to the Berlin Academy in 1839-40. He founded it upon two species, *T. favus* and *T. striolatum*, the former of which is generally taken as the type of the genus." A plate accompanies the article. There is no mention of secondary structure by Mr. Brightwell, only of "larger or minute cellules"; what is now known as the framework of hexagons. A second article from the same pen appears in the July number of the same journal for 1856, increasing the number of species, and is accompanied by another plate.

The next article in the same journal for July, 1858, is by Dr. Wallich, of the Belgian army, on: "*Triceratium* and some near allied forms," accompanied by a plate. There for the first time we find a hint, and a very small drawing of secondary structure in this diatom. There is also an allusion, somewhat obscure, to the possibility of discovering similar structure in other genera of diatoms. Speaking of *T. fimbriatum* (only a variation of *T. favus*), Dr. Wallich says: "Each hexagon in the St. Helen form being, not merely a simple depression dependent upon the mode in which the siliceous element is secreted by the inner cell membrane on its inner surface, but a deep hollow cell, with perpendicular sides of

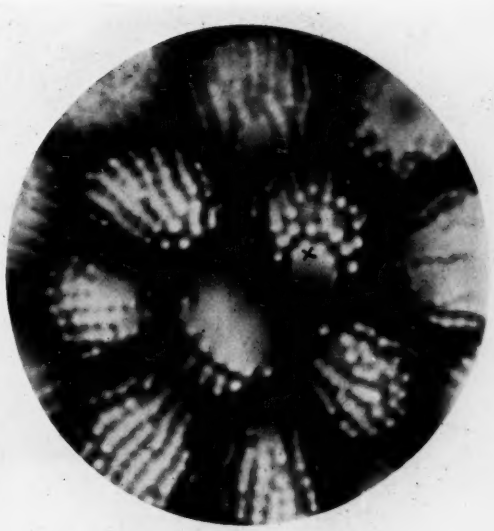

FIGURE 392. *T. favus*, from the centre of the same valve. Magnification—direct—three thousand diameters.

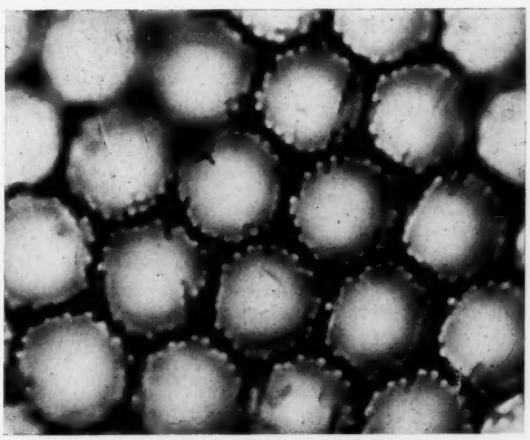

FIGURE 393. *T. favus*, from fragment of another valve, showing nearly all the fibrils torn away, and the covering over the hexagons wanting, where marked. Magnified two thousand diameters.

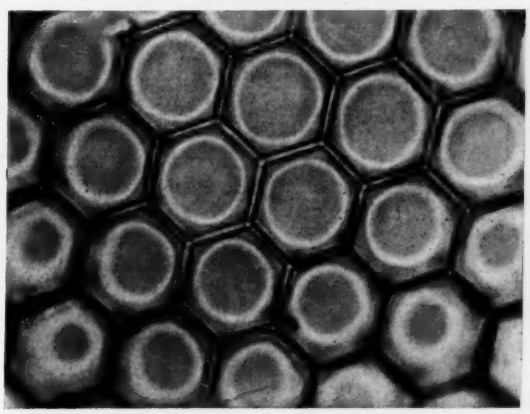

FIGURE 394. The same, showing the hexagons underneath sound. Magnification the same.

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sufficient depth to be readily measured, when seen in fragments and in profile . . . The floor of the cells is also minutely punctate, being arranged in quincunx. The minute puncta require careful illumination and a power of four hundred diameters to render them quite distinct."

We next come to 1872. In a brief communication to *The Lens*—a short-lived American microscopical journal, Dr. Woodward, the eminent American microscopist, says of the "Double Markings of *Triceratium*," of which photographs are enclosed: "When the rows of dots seen in the broken frustule are examined by immersion objectives of the highest power and best quality, they appear with white light as garnet-red beads on a greenish ground, approximating in size and appearance to the beads of *Pleurosigma angulatum*. . . . . The comparative thickness of the frustule, and the marginal walls of the areolae, interfere considerably with clear definition with these high powers; still, I think an impartial examination of the figures will dispel all doubts as to the real nature of the markings."

The above passage is interesting and instructive in even more senses than Dr. Woodward intended at the time of writing. He speaks of immersion objectives of the highest power and quality as being employed to resolve the markings. Oil immersions were not known then, but his own favourite glass was a one-sixteenth inch water immersion of Powell & Lealand with a N.A. of about 1·21. Figure 387 of *T. favus* was taken with a dry, one-sixth inch of 0·85 N.A., and speaks eloquently of what we owe to the new Jena optical glass in producing cheap lenses. This, however, in passing.

That the markings on the floor of *T. favus* and allied species occupied a lower level than the walls of the hexagons, was the commonly received opinion. Indeed, it appears to be the common opinion now. Messrs. Nelson and Karop, in a paper read before the Quekett Club in 1886: "On the Finer Structure of certain Diatoms," say of *T. favus*: "The coarse areolations are hexagonal in form and very deep. At the bottom of these is a delicate perforated membrane, the perforations being circular and arranged for the most part in rows. Figure 3 shows a fracture, passing through the minute perforations, the resolution of which may be considered one of the most crucial tests for the microscope of the present day." The drawing in question shows the walls of the hexagons sharply outlined, with little dots at the corners, which the present writer only finds upon focusing lower down from that side.

It was, in fact, a case of not being able to see the forest for the trees. By the sheerest good luck the writer happened upon one where most of the trees had been felled, as it were, and thus was able to see things in their proper relationship. This is the view he now wishes to place before microscopists through the pages of "KNOWLEDGE." The normal appearance of this diatom is shown in Figure 387 magnified six hundred diameters, yet to be well seen it should be enlarged some three or four times more. Another view would show the white dot instead: only, after all, a question of focus. Figure 388 is part of the same valve magnified two thousand five hundred diameters, in which the white dot is represented.

Then, using the same dry lens, he came upon one looking rather queer. Naturally, the desire was to find out the cause of this divergence from the normal, and a one-twelfth inch oil immersion was substituted, when the appearance was as shown in Figure 389, magnified one thousand five hundred times, taken from one corner of the same valve. It was here simply a question of torn structure spread all over the surface, from which it would have been quite easy to produce another half-a-dozen specimens, had it served any good purpose. Figures 390 and 391, taken on a larger scale from the same valve, and showing the white and black dot aspect respectively, illustrate his views of the normal structure of this side. The reader can take whichever rendering he likes, though one thinks a great deal too much is being made of this white and black dot business. The climax of astonishment is arrived at, certainly, when one hears of ten optical level sections of a diatom photographed between the points of the two dots. These refinements of manipulation seem as little relevant to fact as was the ancient academic discussion: "Whether a thousand angels," or was it ten thousand? "could dance on the point of a needle." It will be seen in Figures 395 and 396 that there is not the slightest difference, either in size or contour, between the two aspects.

The opinion already given, in the article in August and September numbers of "KNOWLEDGE" for last year, was that the conventional appearance of diatoms, at least in the finer forms, is not the real structure. More recent researches of the writer only tend to confirm that opinion, which the various prints presented here should prove. The torn structure of *T. favus* all takes on the same character as the fibrils in *P. formosum* and of the *Pleurosigma* generally. They assume the same zig-zag, or wavy shape, either long or short, as the case may be. In *Pleurosigma* they stretch lengthways upon the valve without interruption from end to end. Here in *Triceratium*, and the discoid forms, they are found in short lengths only, springing from the structureless parts covering the tops of the hexagons immediately above the enclosing walls. Loosely thrown together they are easily torn, and to this we are indebted for the knowledge of their structure. As if to remove the last reasons for doubt, in some instances a single fibril is found sticking out by itself, only connected at one end to the structureless membrane. Figures 390 and 391 illustrate both the zig-zag formation of the fibrils, and how they combine to produce the appearance of the hexagons similar to those on one side of the valve of *P. angulatum*. It must be understood that most of the structure is torn away here, leaving all the more opportunity to judge of the

remainder. Both pictures are taken from the same spot with only just a slight change of focus. Where marked with a × they show in what manner the minute hexagons are formed, one focus presenting them black and the other white.

If the reader will now refer to the article of last year he will find in Figure 18, from the inner side of the valve of *P. angulatum*, a single detached fibril. It is of the usual wavy pattern. On each side is a clear space, and, both above and below, the regular untorn structure, showing how the hexagons are formed by other fibrils.

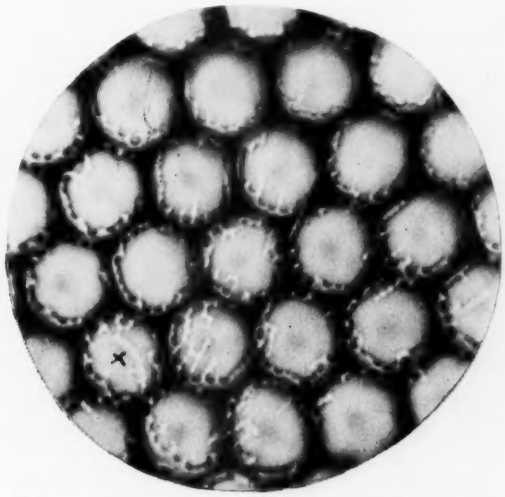


FIGURE 395. *T. favus*, from fragment of another valve, showing the same characteristics of torn structure. Magnified two thousand diameters.

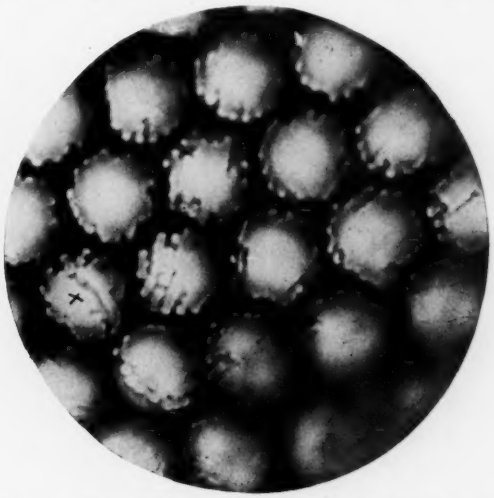


FIGURE 396. The same as last, but at another focus, showing that neither the size nor shape of the irregular structure changes in passing from black dot to white.

Figure 392 of the present article (magnified three thousand diameters) is taken from the centre of the same valve of *T. favus*, and should prove interesting both as an example of high direct magnification and for what it shows. In two divisions the structure is torn away, two fibrils are arranged in a circular direction and behind one, where marked, is seen a series of white dots similar to that we shall find directly in *Coscinodiscus asteromphalus*. Of course, at another focus the dots would be black and the enclosing structure white.

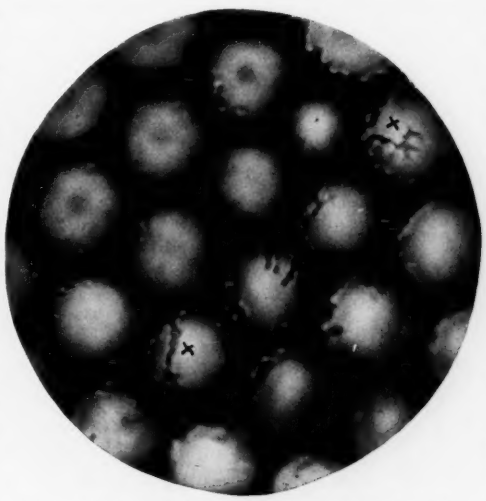


FIGURE 397. *T. favus*, from another part of the fragment. Magnified two thousand diameters.

Figures 393 and 394 are from the fragment of another valve, Figure 397 showing the interspaces almost denuded of fibrils, and Figure 392 the large hexagons immediately underneath. The first Figure should dispose once for all of the opinion that the finer structure lies at the floors of the hexagons. (As a matter of fact they have none.) An irregular-shaped structureless membrane is stretched over the top of them, hiding the contours altogether. Where the ends of the fibrils have been broken off is indicated by the stumps left, and between them are caught little points of light, showing how the focal images are produced when the structure is sound. One fibril, though but faintly shown, is left by itself stretching into space; in another part, marked with a ×, the top covering is torn away entirely; but upon focusing down (Figure 392) the hexagons are untouched. Where the hexagons are ruptured, also, is not the part. Attention is called in this last print to the large discs, characteristic of this genus. They correspond to a great extent to the eye-spots in the discoid forms, only much larger.

The next three figures, 395, 396 and 397, are from the fragment of another valve. Figures 395 and 396 are the same, the focus slightly altered. Figure 397, one view only, is from another part of the same fragment. And here the writer wishes to call attention again to certain peculiarities of structure. He was very much puzzled at this, because they did not conform to his theory, and he could not say in his heart: "So much the worse for the facts." It will be seen, on reference, that Messrs. Nelson and Karop speak of the perforations as circular, and arranged for the most part in rows. Now, given a membrane, in which are either stamped holes or

has bosses raised upon a solid surface, it did not matter one jot for the theory, however irregular.

Unfortunately, the present writer's theory was formed on less elastic lines. Believing that the familiar appearances are not structure at all, but only focal points of light caught between parallel—more or less—rows of fibrils of wavy outlines, the patchy irregularities would not fit in, and they do not. Yet they can be accounted for without destroying his theory, and the reason is apparent in the prints here marked. As a rule, in *Triceratium* the fibrils take the usual zig-zag course, parallel to each other, but in places where they form leaf-like expansions, take on eccentric shapes, and commit other vagaries to puzzle a poor microscopist with new theories of structure. These leaf-like expansions are further shown in two places upon Figures 388 and 392.

(To be continued.)

A BRIEF MATHEMATICAL CONCEPTION OF TELEPATHY.

By L. C. POCOCK, B.Sc.

THE operation of the human brain is more completely shrouded in mystery than is any other function of our body. We have not even an elementary insight into the process by which our brain so precisely stores a thought, recalls the past, or, travelling further into the unknown, influences another brain, producing "Telepathy."

Telepathy is here defined as the action of one brain upon another without any physical contact, and includes Hypnotism when this is effected without contact. When there is contact, there is always the possibility of "muscle reading," or it may be that the sensory nerves in the hand, though accustomed only to reflex action impulses, can also transmit thought impulses which reach them in some way analogous to leakage or conduction from the true brain.

The basis of the present article is one single fact which we do know about the brain. We know that the brain requires nourishment to exercise its functions, and that when called upon to perform extra study, extra nourishment must be supplied. From this it follows that the operation of storing a thought or recalling one already stored is effected by the absorption of a certain amount of energy.

It is an interesting fact that "thinking" is not a reversible process. In committing an idea to memory, and in subsequently recalling it, energy is absorbed, although the one process seems to be the reverse of the other and to represent an opposite function of the brain; in one case we have the reception of an incoming thought, in the other, the formation and production of an outgoing thought. We cannot deliberately forget; forgetfulness is only a slow process represented by the gradual "leakage" or dissipation of that stored energy which was the thought.

We will now consider the possibility of a mathematical expression for cerebral reception and production. To commit to memory a fact we repeat it mentally several times; each repetition requires the expenditure of a certain amount of energy in the brain and we may say the energy expended after n repetitions amounts to

$$1^2 + 1^2 + 1^2 + \ldots \; n \text{ terms.}$$

Subsequently we recall the fact, the brain "produces" it: then even if we consider this process as the reverse of the other, the selection of the arbitrary function as a square gives the change of energy as

$$(-1)^2 = +1^2$$

which therefore represents energy added, or in other words, the effort of recalling a fact strengthens the memory of that fact, which agrees with our experience.

It is possible, however, that for each repetition, the amount of deposit, transformation, or whatever it is that occurs, is for that particular repetition less than for the preceding one; that is to say there is a practical limit to the amount of effect that can be produced. Instead of the series first given we might have one such as

$$\Sigma \left(\frac{1}{f(n)} \right)^2$$

where f(n) continuously increases. If, as seems probable, it is impossible to learn a fact beyond a certain limit equivalent to a saturation of the brain, then this series is convergent.

If we accept this theory and assume that the amount of energy fed to the brain for each term is always the same, it follows that for each succeeding term there is a greater amount of surplus energy to be accounted for. What then becomes of the surplus energy? Energy cannot be destroyed, and must in this case either be frittered away locally, as for example, heat, or it must be radiated directly. Even if none is *directly* radiated, a part is possibly transformed into radiant energy as a consequence of the commutation of thought energy into (as supposed) heat, because energy transformations are rarely completely from one form to one other only, the mechanism of the process usually resulting in some loss as regards the transformation, and the lost energy is often radiated. If we assume that in committing a fact to memory, the energy expended, as the fact becomes more familiar, diminishes in proportion to the effect produced instead of remaining constant—the last argument supports the possibility of radiation, since there is still an energy transformation—from the Potential Energy of nutriment to the Potential Energy of Thought or Brain.

We cannot conceive of force acting at a distance without the interposition of some medium. Electric and magnetic forces are attended by stresses in the aether; light and heat are propagated by wave motion of the same medium. Gravity alone is so familiar to us that we think but little of the process by which two apparently unconnected bodies attract each other. So, in telepathy, when two apparently unconnected brains influence each other it is reasonable to suppose that one radiates energy and the other receives energy and converts it into its equivalent, "thought."

We will postulate that from the considerations stated, telepathy is a case of radiant energy. The immediate result is that we must expect the intensity of action to be inversely proportional to the square of the distance. Such a law has not, however, been observed, and there is, indeed, no evidence that telepathy is even increasingly difficult with increasing distance. But this presents no difficulty. The brain is accustomed to "thinking"; that is to say it is well practised in dealing with thought energy, in storing and radiating energy. As a receiver of external thought energy, however, the brain is far less perfect in consequence of being so little exercised in this capacity; its sensibility and capacity are small, so small that the receiver is saturated, or receives the maximum impression from the feeble intensity existing at even the greatest distance from the primary brain over which telepathy has been observed. In general an excess of energy passes on, unable to produce any effect upon the already saturated brain.

Whether the human brain is slowly improving in its capacity as a receiver, or not, cannot be determined; by all the reasoning of Evolution it is probably not. Professor Drummond points out in "The Ascent of Man" how the need of language to primitive man induced attempts at this art resulting in the evolution of a modified mouth which made possible the modulations and inflections of true language. For telepathy, however, there seems no need at present, and the function, feeble as it is, is not exercised appreciably. It may yet be proved that every feeling of sympathy and affection is the result of unconscious telepathy, and in that case there is no reason that the function should not improve. A new evolution of man may find a conscious use for this wordless thought language; a higher and more delicately made creature than man as he now is, may require this power to call for and express sympathy, to promote true mutual understanding, friendship and affection.

SOLAR DISTURBANCES DURING JULY, 1912.

By FRANK C. DENNETT.

THE Sun's disc only appeared quite free from disturbance on five days during July, namely, from the 20th until the 23rd, and on the 31st. Dark spots, however, were only seen on nine, July the 3rd, and from the 5th until the 12th. Faculae were visible on the remaining seventeen days. The longitude of the central meridian at noon on the 1st was 274° 54′.

No. 9.—A faculic disturbance advancing from the eastern limb was seen on July the 1st and 2nd, around longitude 194°, S. latitude 15°, but on the 3rd a small black pore was seen in its midst, the place being marked by a hazy pore on the 5th, not seen after.

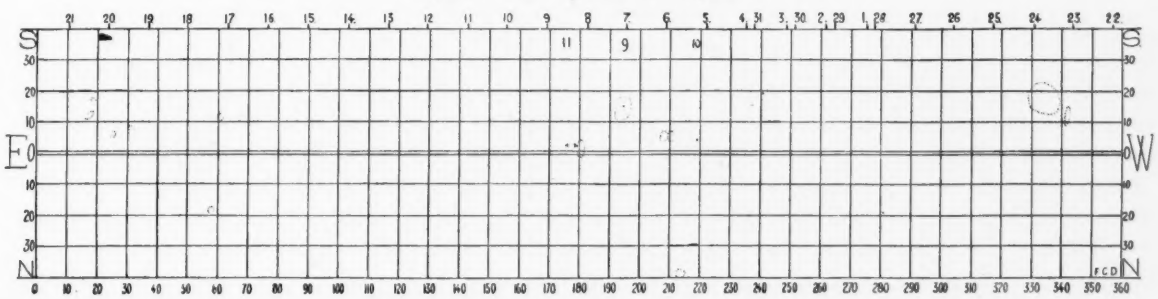
No. 10.—A tiny pore only seen on the 5th.

No. 11.—A small group of pores, traces of which first showed on the 5th. The configuration of the components varied with great rapidity, sometimes in less than an hour. The maximum length was thirty thousand miles. On the 10th at 8 a.m. a group of at least seven pores was seen, but by 7.40 p.m. it was reduced to a solitary pore, which continued visible until the 12th, its faculic remains being seen on July the 13th and 14th nearing the western limb.

A small bright double faculic knot was observed near the western limb in longitude 210° on July the 12th, and two small ones within the eastern limb near longitude 58°, 18° N. latitude, and 61°, 11° South. From the 14th until the 17th, a faculic disturbance was seen at longitude 27°, latitude 7° South, and on the three later days a disturbance was also seen at 19°, 13° South. On the 18th the faculae from longitude 329°—309° were recorded, and a small one on the 24th and 25th at longitude 32°. On the 26th, there was a brilliant knot at longitude 19°. On the 28th a bright region was situated around longitude 213°, North latitude 39°, and the streak in longitude 341°. Also on the 30th a small bright facula was seen close to the equator at longitude 181°.

Our chart is constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, C. P. Frooms, and the writer.

DAY OF JULY, 1912.



THE FACE OF THE SKY FOR OCTOBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Date.	Sun.		Moon.		Mercury.		Venus.		Jupiter.		Saturn.		Uranus.		Neptune.	
	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Oct. 2	12 32·7	S. 3·5	5 29·6	N.28·1	12 29·8	S. 1·7	14 2·2	S. 12·1	16 36·8	S.21·7	4 9·2	N.18·8	20 7·3	S.20·8	7 50·8	N.20·5
,, 7	12 51·0	5·5	10 22·8	N.13·8	13 1·3	5·6	14 25·7	14·4	16 40·3	21·8	4 8·5	13·8	20 7·3	20·8	7 51·1	20·5
,, 12	13 9·3	7·4	14 41·5	S. 18·6	13 31·8	9·2	14 49·8	16·5	16 43·9	21·9	4 7·7	18·7	20 7·3	20·8	7 51·3	20·5
,, 17	13 27·9	9·2	19 18·0	S. 27·5	14 1·8	12·6	15 14·3	18·5	16 47·7	22·0	4 6·7	18·7	20 7·4	20·8	7 51·5	20·5
,, 22	13 46·8	11·0	23 15·6	S. 7·2	14 31·6	15·7	15 39·3	20·2	16 51·7	22·2	4 5·5	18·6	20 7·5	20·8	7 51·6	20·5
,, 27	14 5·9	S. 12·8	3 9·7	N.21·1	15 1·3	S. 18·5	15 4·8	S. 21·7	16 55·9	S.22·3	4 4·2	N.18·5	20 7·8	S.20·8	7 51·6	N.20·5

TABLE 36.

Date.	Sun.			Moon.	Jupiter.						Saturn.	
	P	B	L	P	P	B	L_1	L_2	T_1	T_2	P	B
Greenwich Noon.	°	°	°	°	°	°	°	°	h m	h m	°	°
Oct. 2	+26·2	+6·0	125·7	− 3·3	+ 8·0	−2·6	245·2	6·9	3 9 *e*	9 45 *e*	−3·2	−25·0
,, 7	26·4	6·3	59·8	+20·0	7·6	2·5	313·6	37·1	3 26 *m*	10 59 *m*	3·2	25·0
,, 12	26·4	6·0	353·8	+16·3	7·2	2·5	21·9	67·3	9 15 *e*	0 13 *m*	3·1	25·0
,, 17	26·3	5·6	287·9	− 7·5	6·8	2·5	90·2	97·5	9 32 *m*	7 15 *e*	3·1	24·9
,, 22	25·9	5·2	221·9	−21·5	6·4	2·5	158·5	127·6	5 31 *e*	8 29 *m*	3·1	24·9
,, 27	+25·3	+4·7	156·0	−14·3	+ 6·0	−2·5	226·8	157·7	5 48 *m*	5 35 *e*	−3·0	−24·8

TABLE 37.

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zones. T_1 T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN moves South pretty rapidly. Sunrise during October changes from 5–59 to 6–53; sunset from 5–41 to 4–35. Its semi-diameter increases from 16′ 0″ to 16′ 9″.

MERCURY is in superior conjunction with the Sun on October 4th, and may be seen in the evening at the end of the month, especially by Southern observers. Throughout the month the disc is nearly fully illuminated, semi-diameter $2\frac{1}{2}''$.

VENUS is an evening Star, but too near the Sun for convenient observation. Illumination nearly complete, semi-diameter $5\frac{3}{4}''$.

THE MOON.—Last Quarter $3^d\ 8^h\ 48^m e$; New $10^d\ 1^h\ 41^m e$; First Quarter $18^d\ 2^h\ 6^m m$; Full $26^d\ 2^h\ 30^m m$. Perigee $7^d\ 7^h e$, semi-diameter 16′ 23″; Apogee $19^d\ 2^h e$, semi-diameter 14′ 48″. Maximum Librations, October 3^d 7° S., 13^d 6° W., 17^d 7° N., 26^d 5° E. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

MARS is an evening Star, but practically invisible.

JUPITER is an evening Star, increasing its distance from us, so that the equatorial semi-diameter diminishes from 17″ to 16″. The Polar is smaller by $1\frac{1}{4}''$. The configurations of the satellites at $6^h e$ are for an inverting telescope.

Date.	Star's Name.	Magnitudes.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. to E.	Mean Time.	Angle from N. to E.
1912.			h. m.		h. m.	
Oct. 2 ...	136 Tauri	4·6	9 8 *e*	109°	9 53 *e*	233°
,, 4 ...	ω^2 Cancri	6·2			11 4 *e*	293
,, 5 ...	λ Cancri	5·9	6 38 *m*	168	7 16 *m*	230
,, 6 ...	BD+21° 1969	7·7			0 43 *m*	210
,, 20 ...	29 Aquarii (double)	6·5	4 18 *e*	40	5 27 *e*	269
,, 26 ...	36 Arietis	6·5	8 54 *e*	106	9 40 *e*	191
,, 27 ...	BD+22° 523	7·0			10 5 *e*	270
,, 28 ...	BAC 1170	5·5	2 18 *m*	91	3 28 *m*	234
,, 29 ...	BAC 1746	6·5	7 59 *e*	47	8 44 *e*	290
,, 30 ...	BAC 1848	5·6	2 27 *m*	114	3 35 *m*	239
,, 31 ...	*c* Geminorum	5·5	8 50 *e*	101	9 40 *e*	266

TABLE 38. Occultations of stars by the Moon visible at Greenwich.

From New to Full disappearances occur at the Dark Limb, from Full to New reappearances.

Day.	West.	East.	Day.	West.	East.
Oct. 1	3 ○	41 2●	Oct. 17	4/3 2 ○	1
,, 2	31 ○	24	,, 18	21 ○	43
,, 3	2 ○	14 3●	,, 19	○	2/1 43
,, 4	21 ○	34	,, 20	1 ○	234
,, 5	○	1234	,, 21	2 ⊙	14
,, 6	○	234 1●	,, 22	32 ○	4 1●
,, 7	231 ○	4	,, 23	31 ○	24
,, 8	3 ○	14 2●	,, 24	3 ⊙	14
,, 9	31 ○	42	,, 25	21 ○	34
,, 10	423 ○	1	,, 26	○	4213
,, 11	421 ○	3	,, 27	41 ○	23
,, 12	4 ○	123	,, 28	42 ○	1/3
,, 13	41 ○	23	,, 29	432 ○	1●
,, 14	423 ⊙		,, 30	431 ○	2
,, 15	432 ○	1	,, 31	43 ○	21
,, 16	4/3 1 ○	2			

TABLE 39.

Satellite phenomena visible at Greenwich, $1^d\ 6^h\ 39^m\ 54^s$ II. Ec. R.; $3^d\ 5^h\ 50^m$ III. Oc. D.; $5^d\ 7^h\ 33^m$ I. Tr. I.; $7^d\ 5^h\ 23^m$ I. Sh. E.; $13^d\ 6^h\ 42^m$ I. Oc. D.; $14^d\ 6^h\ 18^m$ I. Tr. E., $6^h\ 46^m$ III. Sh. E.; $15^d\ 7^h\ 13^m$ II. Oc. D.; $17^d\ 6^h\ 8^m$ II. Sh. E.; $21^d\ 6^h\ 3^m$ I. Tr. I.; $22^d\ 6^h\ 19^m\ 22^s$ I. Ec. R.; $24^d\ 6^h\ 1^m$ II. Sh. I.; $29^d\ 5^h\ 13^m$ I. Oc. D; $30^d\ 4^h\ 49^m$ I. Tr. E., $5^h\ 37^m$ I. Sh. E.

All the above are in the evening hours.

The eclipse reappearances of I. II. and both phases of those of III. occur high right of the inverted image, taking the direction of the belts as horizontal.

SATURN is a morning Star. Polar semi-diameter $9\frac{1}{4}''$. The major axis of the ring is $46\frac{1}{2}''$, the minor axis $19\frac{1}{2}''$. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

East elongations of Tethys (every fourth given). October $2^d\ 2^h{\cdot}1\ e$, $10^d\ 3^h{\cdot}3\ m$, $17^d\ 4^h{\cdot}5\ e$, $25^d\ 5^h{\cdot}7\ m$. Dione (every third given). October $2^d\ 11^h{\cdot}2\ m$, $10^d\ 4^h{\cdot}2\ e$, $18^d\ 9^h{\cdot}2\ e$, $27^d\ 2^h{\cdot}2\ m$.

Rhea (every second given). October $2^d\ 5^h{\cdot}2\ e$, $11^d\ 5^h{\cdot}9\ e$, $20^d\ 6^h{\cdot}7\ e$, $29^d\ 7^h{\cdot}3\ e$.

For Titan and Iapetus, E. W. mean East and West elongations, I., S. Inferior and Superior Conjunction, Inferior being to the North, superior to the South. Titan, $3^d\ 5^h{\cdot}6\ m$ W., $7^d\ 4^h{\cdot}2\ m$ S., $11^d\ 7^h{\cdot}3\ m$ E., $15^d\ 7^h{\cdot}9\ m$ I., $19^d\ 3^h{\cdot}6\ m$ W., $23^d\ 2^h{\cdot}0\ m$ S., $27^d\ 5^h{\cdot}1\ m$ E., $31^d\ 5^h{\cdot}5\ m$ I. Iapetus $4^d\ 5^h{\cdot}8\ e$W, $23^d\ 2^h{\cdot}6\ e$ S.

URANUS is an evening Star, semi-diameter $2''$. It is $7\frac{1}{2}°$ South of Alpha Capricorni, 5° South-West of Beta.

NEPTUNE is a morning star, not yet very well placed.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
July to Oct...	355°	+ 72°	Swift, short.
Aug. to Oct. 2	74	+ 42	Swift, streaks.
Sept. 28 to Oct. 9	320	+ 40	Slow, small.
Oct. 2 ...	230	+ 52	Slow, bright.
,, 4 ...	310	+ 79	Slowish.
,, 8 ...	77	+ 31	Swift, streaks.
,, 8—14	45	+ 58	Small, short.
,, 14 ...	133	+ 68	Rather swift.
,, 15 ...	31	+ 9	Slow.
,, 18 - 20	92	+ 15	Swift, streaks.
,, 23 ...	100	+ 13	Swift, streaks.
,, 29 ...	109	+ 23	Very swift.

CLUSTERS AND NEBULAE.

Name.	R.A.	Dec.	Remarks.
M. 52	$23^h\ 20^m$	N 61°·1	Cluster.
♓ IV. 18	23 22	N 42 ·0	Spiral nebula.
♓ VI. 30	23 52	N 56 ·2	Cluster.
♓ V. 18	0 35	N 41 ·1	Large faint oval nebula
M. 31	0 37	N 40 ·8	Great nebula in Andromeda.
M. 32	0 37	N 40 ·8	
♓ VIII. 78	0 38	N 61 ·3	Cluster "Like letter W" Between γ and κ Cassiopeiae.

DOUBLE STARS.—The limits of R.A. are 23^h to 1^h.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Angle. N. to E.	Distance.	Colours, etc.
94 Aquarii	23 15	S 13°·9	5, 7	349°	13″	Yellow, blue.
o Cephei	23 16	N 67 ·6	5, 8	199	3	Yellow, blue.
Lalande 47034	23 55	N 33 ·2	6, 6	215	2	Yellowish.
Lalande 47206	0 0	N 33 ·8	7, 7	152	1/2	Yellow.
	There is a ninth mag. star, distant 23″.					
Bradley 3210	0 2	N 58 ·0	7, 8	354	1½	Yellow, bluish.
	Period of revolution, 114 years.					
Bradley 3217	0 5	N 79 ·2	6, 7	140	1/3	Yellow.
55 Piscium	0 35	N 21 ·0	5, 8	191	7	Yellow, purple.
η Cassiopeiae	0 44	N 57 ·3	4, 8	240	6	Yellow, purple.
	Period of revolution, about 213 years.					
65 Piscium	0 45	N 27 ·2	6, 6	117	4	Yellowish.
36 Andromedae	0 50	N 23 ·2	6, 7	21	1	Yellow.

TABLE 40.

CORRESPONDENCE.

STEREOSCOPIC STAR CHARTS.

To the Editors of "KNOWLEDGE."

SIRS,—I have read with interest the article in your June number by Mr. A. H. Stuart, on Stereoscopic Star Charts. I should have left to Mr. T. E. Heath the task of commenting on the question of priority as to his method of graphically illustrating the relative distances of the stars, but for the fact that the author makes the statement that stereoscopic lantern slides of stars have been placed on the market by "an American firm." It was as long ago as May, 1906, that Mr. T. E. Heath, F.R.A.S. approached my firm (Flatters and Garnett, Ltd.) and I then undertook some experiments with a view to reproducing, by a photographic process, the stereographic charts and transparencies which Mr. Heath had prepared. He had been successful in making the slides by

hand from sheets of gelatine, one red and one green, with the stars pricked out as holes in such a way that when superimposed the "pairs" of stars (red and green) showed up brightly on a very dark purple background. It is needless to recapitulate the many experiments undertaken, but some details of the technique finally adopted and still (with some modifications) pursued by my firm, may be of interest:—

(1) Mr. Heath drew a pair of large scale star maps of each selected area. The same stars were shown on each half, but their positions laterally varied with their differences in parallax. The stars were drawn as black discs on a white ground—their diameter varying with their magnitude.

(2) From each half of the chart a negative was prepared on exactly the same scale, and of a size suitable for a lantern slide—one half (the right) was reversed, *i.e.*, taken through the back of the plate, for reasons that will presently be evident.

(3) From these negatives—(white stars on a black ground) fresh positives were now prepared, in which the stars were once more black on a white ground.

(4) The next step was the sensitizing—by a modification of the bichromate or carbon process—gelatine films on glass plates three and a quarter inches by three and a quarter inches. When dry, these films were printed from the positives obtained in (3), and, after exposure, developed in the usual way of carbon printing with warm or hot water. If successful, the stars, being unacted on by light, washed out completely, leaving bare glass, the background being still strongly adherent and insoluble.

(5) The right-hand slide was then bathed in a dye bath of the correct red tint, and the left hand one in a bath of green dye. The dyes were selected so as to be as near as possible complementary, so that when viewed together by transmitted light the films were nearly opaque (really a very deep purple blue).

(6) On now placing the two halves with the films face to face, the holes in the red half appeared green, while those in the green appeared red. It will now be seen why it was needful to reverse one half. If not reversed the one film would have had to have been placed to the outside of the slide, which would not have answered.

(7) Finally the slides were bound up into position; any little errors of printing resulting in the pictures not coinciding being adjusted before binding. On viewing against a light, or on a screen, each pair of stars now shows up as a red and green disc, the star in each pair varying in distance from its fellow. Thus, the most distant stars almost touch, while the nearer ones are some way apart. Spectacles with suitably coloured gelatine glasses are put on when looking at the slides, when the pairs combine as one star and stand out apparently in mid-air.

A curious phenomenon may here be mentioned; if the red glass is held to the right eye, and the green to the left, *i.e.*, in the same position as the colours on the slides, the stereoscopic effect is still seen, but the stars appear to stand out *behind* the screen, and the nearest stars are seen as most distant; with the spectacles reversed, the nearest star approaches apparently nearest to the eye, in front of the screen.

Later, large transparencies, to hang in windows, were prepared, and to my mind these are more beautiful and effective and easier to see stereoscopically than the lantern slide projected on a screen. For the later the disc should be small, and the audience at a fair distance from the screen.

Perhaps the most unexpected truth that these stereograms have demonstrated to the public is that the largest stars are not necessarily the nearest!

HENRY GARNETT, F.C.S.

32, DOVER STREET,
MANCHESTER.

[We are pleased to announce that Messrs. Flatters and Garnett are still prepared to make slides of the transparencies in question.—EDS.]

SPECIAL APPEAL FROM THE RESEARCH DEFENCE SOCIETY.

To the Editors of "KNOWLEDGE."

SIR,—We are of opinion that experiments on animals in this country should be restricted by law, that the present Act should be efficiently administered, and that the utmost care should be taken to ensure the minimum of pain in these experiments.

Some of the anti-vivisection societies have lately adopted methods which are grossly offensive to the public interest. They have opened no less than sixty shops in London and elsewhere. Most of these shops have lasted only a few weeks: but they have had time to spread falsehood, prejudice, hatred, and suspicion against scientific research. They have also done harm to small children. It is no light offence to exhibit in public not only brutal cartoons and caricatures, but stuffed animals, tied down for operation, while the truth is carefully concealed that no operation is allowed on any animal in this country, except under an anaesthetic.

In this connection, we would remind the public of the unanimous statement of the Royal Commission:—"To represent that animals in this country are wantonly tortured would in our opinion be absolutely false."

The excuse is offered, for these shops, that the appliances displayed in the window are actually supplied by the makers. But if the appliances used in our Hospitals were displayed in a shop-window, with models of human beings tied down for operation, it would be no excuse for such a travesty, to say that the appliances had actually been supplied by the makers.

Some of these societies, having wealth at their disposal, are able to rent shops in the most crowded thoroughfares, or to attract, by the very lavish and rather unscrupulous use of money, a large audience. It seems that an effort is being made to work on the mere liking for horrors, real or sham: that no exhibit is too sensational, if it can serve to draw attention and to excite passion.

When we think of the vast multitudes of lives, human and animal, saved from pain, disease, and death, by discoveries made through experiments on animals, we cannot believe that the present methods of anti-vivisection societies are acceptable to sensible and honest people.

The only way to fight these methods is to be constantly publishing the facts of the case put before the Royal Commission and embodied in its final Report. The Research Defence Society, in the past twelve months, has given more than a hundred addresses and lantern lectures in all parts of the kingdom, and has distributed more than half-a-million pamphlets and leaflets. But there is much more work waiting to be done, if we had the money for it. We therefore appeal for special donations, to be controlled by the Committee of the Society, and to be used solely for such purposes of education as public lectures and distribution of literature. All cheques should be crossed Messrs. Coutts & Co., and made payable to the Hon. Treasurer, Research Defence Society, 21, Ladbroke Square, London, W. We hope and believe that this appeal, in the interest of the public, will be very generously answered.

On behalf of the Society,

We remain,

Yours faithfully,

DAVID GILL, President.
SYDNEY HOLLAND,
Chairman of Committee.
ROBERT CECIL.
LUKE FILDES.
WILLIAM RAMSAY.
MARY SCHARLIEB.
F. M. SANDWITH,
Honorary Treasurer.

21, LADBROKE SQUARE,
LONDON, W.

THE ROTATION OF VENUS.

To the Editors of "KNOWLEDGE."

SIRS,—By an error of reduction the period determined by Mr. J. McHarg is given on page 305 as $23^h\ 28^m\ 13^s{\cdot}595$, he however, has kindly pointed out that it should be ·9776803 days, or $23^h\ 27^m\ 51^s{\cdot}58$. I should, therefore, be glad if you would kindly insert the correction.

FRANK C. DENNETT.

THE SECOND LAW OF THERMODYNAMICS AND PROFESSOR BICKERTON'S THEORY.

To the Editors of "KNOWLEDGE."

SIRS,—*The English Mechanic*, of August 2nd, reprints an article from *The General Electric Review*, by C. P. Steinmetz, Chief Consulting Engineer of the General Electric Company, on "The Death of Energy." This article confirms Professor Bickerton's views published in the December number of "KNOWLEDGE," in which he shows that the second law of thermodynamics is not of cosmic application, and that the eternity of life is physically possible. Steinmetz's article commences by a very full and varied series of illustrations of dissipation of energy. He then goes on to say:—"The second law of thermodynamics is well founded on our experience. The reasoning from this law as to the death of the universe is logical. At the same time, the conclusion that the universe must run down is not reasonable. If the universe is eternal, has existed since infinite time, then it should have run down an infinite time ago. But if it is not eternal, but had a beginning, what was before? Thus, in the final reasoning, we arrive at a contradiction. The explanation may be either that we have attempted to reason beyond the limits of the capacity of the human mind, which, being finite, always fails in the attempt to reason into the infinite, or it may be that the second law of thermodynamics is not of universal application; is not a general law of nature, but is of limited application only. In the following pages I wish to show that the latter is the case. A single exception, obviously, would be sufficient to show that the second law of thermodynamics is not a universal law, and that the conclusions regarding the death of the world, based on this law, are thus not justified. As the thermodynamics of gases is far simpler and more completely known than any other branch of thermodynamics, it would offer the most promising field of study. The kinetic theory of gases is probably as fully and conclusively proven as anything can be, by the inductive method of science." The author then discusses Clark Maxwell's demons, and says "Now, these demons exist in Nature. Every cosmic body is such a demon, and separates the fast from the slow molecules, keeping the latter and sending the former out into space, and thereby causing heat energy to flow into space, at a temperature far above its own temperature. . . . . If, however, the upward velocity of the molecule is sufficiently high — above a certain critical value — then this molecule escapes from the attraction of the earth into space, and never comes back." Then Steinmetz shows, as Bickerton has previously done, that molecular motion may cease to be heat. He says: "We may ask, however, whether the kinetic energy of a molecule which, due to its high velocity, has escaped into cosmic space, can still be considered as heat energy. Heat energy is the kinetic energy of irregular molecular motion. The difference between the heat energy of a gas and mechanical energy thus lies in the irregularity of the motion and the size of the moving particles, which is such that only the resultant effect of the mechanical motions of large numbers of moving particles can be perceived. Irregularity of motion, however, is relative; for if we consider a single molecule which has escaped into space, by reason of its high velocity, we cannot attribute any irregularity to its motion. That is to say, its kinetic energy cannot further be considered as heat energy; but the kinetic energy of the molecule, which has heat energy, while the molecule moved in a mass of gas together with other molecules, is mechanical energy of cosmic motion, and the molecule is a cosmic body traversing space under the laws of gravitation, but not subject any more to the law of probability of mass action—*i.e.*, to the second law of thermodynamics." He then shows by very lengthy argument that this new energy is not heat, and says—"When, however, the kinetic molecular energy ceases to be heat energy, the second law of thermodynamics, which is the application of the law of probability, also ceases."

He then gives a long discussion showing that this new energy clearly does not conform to Kelvin's law, and concludes by saying—"We are thus led to the conclusion that the second law of thermodynamics is not a universal law of Nature, but applies only within the limited range of thermodynamic engines from which it has been derived. It does not apply to the universe as a whole; and the conclusions derived from it, that the universe must finally come to a standstill, are not justified."

Clearly Steinmetz has been led to this view by his own independent reasoning, his terms being wholly different from Bickerton's. When it is considered that Bickerton used the term, "selective molecular escape" and showed that it overcame dissipation of energy, a third of a century ago, it is obvious he has the priority of the idea. It will be observed also that Steinmetz says nothing of the "aggregating power of the position of high potential" which Bickerton shows to be a cosmic collecting agent for light elements in contrast to gravitation, which tends to collect and concentrate heavy elements. In this way Bickerton shows that both sides of the doctrine of physical death, namely, the degradation of energy and the concentration of matter, have each of them agents acting in the opposite direction. So that the whole cosmic scheme is like the differential governor of a steam engine, constantly tending to equilibrium.

In the August, 1911, "KNOWLEDGE," in Physics notes, you gave Kapteyn's observations that tended to confirm Bickerton's theory of the origin of the universe. In the June meeting of the B.A.A., fully reported in their journal, Bickerton shows that the Cambridge series of the spectrograms not merely demonstrated that Nova Geminorum was actually a third body struck from grazing suns, but that these spectra also exhibited most clearly the action of axial extrusion of selective molecular escape, and the pulsation of the nucleus, described in the September number of "KNOWLEDGE." Thus it seems that all the essential facts of the New Astronomy are demonstrated by independent observations and reasoning.

SYLVESTER N. E. O'HALLORAN.

GRAY'S INN.

FERTILIZATION OF THE FIG.

To the Editors of "KNOWLEDGE."

SIRS,—I should be very grateful if Professor Cavers would point out how far his very interesting paper on "The Fertilisation of the Fig" is applicable to the fig of our English gardens. As far as I have been able to observe there are no small wasps frequenting the trees, nor have I seen apertures at the top of the pear-shaped receptacle large enough to admit any but the very smallest insect. Neither can I find the three crops of inflorescence spoken of. I am sure any information on the subject would be welcomed gratefully by all interested in such a branch of botany.

I. L. J.

DISCAL FLORETS OF COMPOSITAE.

To the Editors of "KNOWLEDGE."

SIRS,—Sir W. W. Strickland* appears to be endeavouring to construct a theory of the arrangement of disc florets on a basis of concentric circles, but Nature really knows nothing of circles, only *spiral whorls*, resulting from the projection of portions of a continuous spiral on to a plane. For example, the aestivation of the lobes of gamopetalous corollas reveals

* "KNOWLEDGE," August, 1912.

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this fact, though the united petals may form a cylindrical tube with a circular section.

In reducing the florets to circles, as shown in Figure 330, the result is not in accordance with Nature; for if a large sunflower be examined, it will be seen that it is just like a suppressed cone, the florets being arranged in *radial curves*, corresponding to the secondary spirals on a fir cone; these curves are like the ornamentation on the back of a watch, only the curved radii are thirty-four and fifty-five respectively, running in opposite directions. These supply the divergence $\frac{34}{89}$ in the usual way of the generating spiral.

Inexactnesses are always liable to occur in crowded structures, in consequence of the suppression of some; so that the true maxima have usually subordinate ones on either side of them; but the origin is *always spiral* and not *circular*. Of the "three possibilities" the author gives, the first, that "the discal florets may represent phyllotaxis numbers or their doubles" is the only one possible, except multiples of fives; but these only occur in simpler conditions, as in pentamerous flowers.

For further details I would refer any reader interested in phyllotaxis to my several papers in the *Transactions of the Linnean Society*.

BOURNEMOUTH. GEORGE HENSLOW.

REVIEWS.

ASTRONOMY.

Astrographic Catalogue. 1900·0. Perth Section. Dec. − 31° to − 41°. Vol. I.—By W. ERNEST COOKE, M.A., F.R.A.S. 52 pages. Vol. IV. 72 pages. 12-in.×9¾-in.

(Perth, Australia: Fred. W. Simpson.)

We welcome these portions of two volumes, though small, from the Perth Observatory, W. Australia, as being the first that have yet been published concerning any portion of the southern half of the sky, except a small section near the equator from Algiers. We usually associate clear skies with the southern hemisphere; but, considering that all the eighteen participating observatories started or might have started this survey work in 1892 (the Perth Observatory was only founded in 1896 and agreed to take on the section which was at first allotted to Rio de Janeiro) we must either modify our opinions or assume that the great delay in making the preliminary results of the survey available for astronomers is solely due to want of energy and proper organization. As we are well acquainted with the various reasons for the delay we can say that the sky has not been the cause; this might well have been advanced as the cause at three northern observatories, Helsingfors, Greenwich and Oxford, but the last two have alone, of the eighteen, measured and published their portions, about two hundred thousand stars each.

The two sections with which we are now concerned contain five thousand six hundred and forty-six and thirteen thousand six hundred and thirty-six star images in −32° zone, R.A. 0^h to 6^h, and 18^h-0^h. The size of the page is that of Greenwich and Oxford, and the general arrangement of the material on the pages closely resembles that adopted at Oxford. The points of difference are, that three instead of five groups of columns are put on a page—we think four would have been best; that undue space—two wide columns—is given to the magnitudes; and that instead of making the numbering in sequence for a whole zone it starts with one for each plate; as there are one hundred and sixty plates in each zone that means there will have to be one hundred and sixty breaks and the same numbers will be repeated one hundred and sixty times—or at least the first hundred or so—in the same zone. The only distinguishing point in each instance will be the R.A. of the plate centre; so we must use a cumbersome notation. Brevity is what we should aim at, and say a star is

−32° R.A. 5^h 51^m No. 229

instead of

−32° 5646.

The non-repetition of the *reseau* interval where it changes in *y* is a source of error in the practical use of the work. There is room for much economy of space or printing; when a plate ends, the rest of the column is left blank: the blank space on a page is frequently one quarter to one half of the page. We thought paper and printing were expensive in Australia. If we take Vol. I, R.A. 0^h-6^h, the measures occupy thirty-four pages of three columns each; in those pages there is an equivalent of more than nineteen blank columns, thus about twenty *per centum* of the whole is wasted. Economy might be considered here. We venture to urge that the name of the Observatory, Perth, should be printed on each page, as there will be Astrographic Catalogues from seventeen other observatories! though we do not expect them all to be available for astronomers' use before 2000.

In the methods of measurement and reductions, and in the formation and arrangement of the tables for reduction, those brought into use by Professor Turner (Oxford) have been closely followed: it is of the greatest advantage to have some uniformity in this international survey work, though unlimited time and money *might* produce better results. The magnitudes are designated by letters according to Mr. W. E. Cooke's own scheme, explained on pages 8 and 9 of Vol. I.

Though we congratulate Mr. Cooke in having set the lead for the southern sections, especially as he started some years later (Algiers work is just the part to the north and south of the equator), we should have preferred even a little more delay and got a complete volume out at a time; this would save cost in binding and time in distribution; the numbering might have then run on from plate to plate.

F. A. B.

Catalogue of 2,043 Stars between 35° and 37° S. Dec.—By W. ERNEST COOKE. 122 pages. 12¼-in.×10-in.

(Fred. W. Simpson.)

The book before us is the fifth of this series of meridian observations made with the Troughton & Simms six inches in diameter object-glass at the Perth Observatory, West Australia.

This volume contains the positions of two thousand and forty-three stars between − 35° and − 37° declination derived from observations made so recently as in the year 1910. This speedy publication of a considerable catalogue of meridian work is highly commendable to Mr. W. E. Cooke and the assistants who contributed the bulk of the work, and is quite contrary to the usual long interval between observations and publication. It is a valuable catalogue for southern astronomical photography.

The primary object of this series of catalogues is to provide good meridian places for those stars upon which to base the corrections of the photographs being taken at Perth for the Astrographic Survey. A minimum of three stars scattered over each square degree is aimed at; that would afford twelve to fifteen reference stars on each plate; being observed nearer the epoch at which the photographs are exposed than is usual, the proper motions have a less disturbing effect. An average of three observations for each star has been maintained. We notice that the observational work depended upon Mr. H. B. Curlewis for the transits, and Mr. C. Nossiter for the microscope readings; it is an important point not to have varying observers in meridian work. As quite fifty *per centum* of the stars are below the ninth magnitude we do not find that any allowance has been made for magnitude-equation; 9·5 to 10·5 magnitude stars are not easy to observe with a six-inch lens. Was any change made in the method of observing these and the brighter stars?

The catalogue itself occupies sixty-four pages; there are two appendices of fifty-eight pages consisting of blank forms for writing in corrections, as explained in Volume IV; such are of use at the Perth Observatory, but we do not think

these pages will be used elsewhere: a publication containing a summary of the corrections for the whole zones would have been of greater use.

We have one criticism to make upon this and previous volumes of this series. We offer a protest against the absurd custom, originated or frequent in American publications, of inserting useless cyphers before whole numbers, such as minutes and seconds; *e.g.*, Why $1^h\ 02^m\ 08^s{\cdot}24$? Why not $1^h\ 2^m\ 8^s{\cdot}24$?

F. A. B.

Memoirs of the British Astronomical Association.—Section—Comets. Vol. XIX, Part I.

(Eyre & Spottiswoode. Price 1/6.)

The recent publication of this number brings to the front again old Halley's Comet. We have here a summary of the work of the Association's observers, and some others, upon the history, brightness, nucleus, coma, tail, spectrum, and other phenomena, written up in twenty-eight pages, by Dr. D. Smart. The second part, the orbital data, is written by Dr. A. C. D. Crommelin, whose collaboration with Dr. Cowell brought so much honour and credit to themselves and to this country, and he gets a large amount of valuable information in a concise form into six pages, illustrated with diagrams. The third part, six pages and two plates is replete with illustrations of the nucleus and tail of the comet.

F. A. B.

Stars and Constellations: A Little Guide to the Sky.—By AGNES FRY. 40 pages. 2 maps. $6\frac{1}{2}$-in.$\times 5\frac{3}{4}$-in.

(Clifton: J. Baker & Son. Price 6d. net.)

This booklet describes in poetic language the march of the stars during the year. We had the advantage of reading the manuscript of these lines; now we have them in print, in a neat form, in excellent type and a good paper, at a trivial cost. The authoress gives more than a line for each day of the year: there are four hundred and one lines; occasionally the rhyme or rhythm appears somewhat crude, but we do not notice any errors in the fanciful descriptions of the constellations.

To those who like to associate the constellations with verse we commend this booklet as a useful aid in remembering the configurations.

F. A. B.

BACTERIOLOGY.

Bacteria as Friends and Foes of the Dairy Farmer.—By WILFRID SADLER. 112 pages. 8 illustrations. $7\frac{3}{4}$-in.$\times 5$-in.

(Methuen & Co. Price 1/6.)

Now that preservatives are no longer allowed in milk there is an additional reason why those who are responsible for its keeping should become familiar with the bacteriology of the dairy. The old practical methods of butter and cheese-making may be very successful, and it is always advisable to let well alone; but when difficulties arise the application of scientific methods and principles will be found most advantageous. Mr. Sadler deals with the question of pure milk supply and germ-free milk, as well as with the sources of contamination, while the first part of his book is occupied with some introductory remarks on bacteria, acid forming germs and the production of flavour by them. In his Introduction Mr. John Golding, speaking of the dairy farmer, says that it has become an absolute necessity that he should be acquainted with some knowledge of the world of microscopic beings with which he is beset on all sides, and be able to distinguish his friends from his foes among this host which he cannot see; but to which he owes, and from which he fears, so much.

BIOLOGY.

Second Report on Economic Biology.—By WALTER E. COLLINGE, M.Sc., F.L.S., F.E.S. 70 pages. 9-in.$\times 6$-in.

(The Midland Educational Co. Price 2/6.)

We have before us the second report on Economic Biology which deals with the year 1911, and in his introduction Mr. Collinge says that the losses occasioned by injurious insects and other animals and fungus parasites during the year 1911 have far exceeded anything he has previously known. The prolonged and dry summer resulted in the maximum number of broods being produced, whilst the drought told largely against the vitality of many crops, thus rendering them unable to ward off the effects of insect or fungus attacks. On some farms and in many orchards the conditions have been pitiful; indeed, those who have taken all precautions have been no light sufferers.

A new pest of mangels and beet in the shape of *Cionus scrophulariae* Linn., which was first of all found on knotted fig-wort, has now been recorded as damaging the leaves of cultivated plants. Mr. Collinge discusses its distribution and life history. In the miscellaneous notes some observations on the food of the starling are given. The crops of one hundred and forty-six birds were examined during the first six months of the year. Mr. Collinge says that the food was of a distinctly insectivorous character in the vicinity of the city of Birmingham, and that during those months the evidence from the food generally would lead us to place this species amongst those birds beneficial to the agriculturist and horticulturist. He, however, adds that a similar record taken in an agricultural district would "in all probability reveal the starling as the destroyer of newly-sown grain, and extended over the summer months would show that it inflicts considerable losses upon fruit growers," and he further remarks "in short, we have too many starlings." He is most likely quite right, but it would be useful to have some direct evidence as to the second six months of the year; and, as the natural outcome of having too many starlings would be to destroy them, the question arises why should they be killed in the neighbourhood of Birmingham if they are there useful. Possibly, however, it might be contended that they might migrate to an agricultural district. We should, however, like to know also how the economic biologist decides whether the amount of good done by any particular bird outweighs or balances the harm which it causes.

COSMOLOGY.

The Growth of a Planet.—By EDWIN SHARPE GREW, M.A. 351 pages. 9 illustrations and numerous diagrams. $7\frac{1}{2}$-in.$\times 5$-in.

(Methuen & Co. Price 6/- net.)

This is a class of book that at the present time is most urgently needed. From cover to cover it teems with original thought and sane suggestion. It is a careful examination of a large number of cosmic explanations, theories, and generalizations. Many of our eminent scientific thinkers have been deploring the fact that we stand a chance of being intellectually buried beneath the vast accumulations of unclassified and badly correllated facts. The last few years has shown that there is a tendency amongst scientific men generally to search for explanations and working hypotheses. It was only natural that in the past the stupendous advance in the power of our telescopes, then their being armed first with the prism and then with the photographic film, should give a great enthusiasm to observations. This book is an attempt to find out what these observations mean and their constructive value. It must aid greatly in giving order to our ideas, and will tend to introduce a system of logical classification that will render observations available for future study.

The book opens with an examination of the theories of the Birth of Systems. Professor See, in his Capture theory, shows many grounds why Laplace's ring theory must be abandoned; our author shows us many more. Having relinquished this hypothesis, he examines Chamberlin and Moulton's and shows reasons why we must accept this hypothesis with a great deal of caution. Of course, one of the most fatal objections to this theory is, that where double spiral nebulae are abundant, there are but few stars to produce them, and where stars are abundant they appear to have formed no spiral nebulae at all. Another objection is, that we should expect to find many double spiral nebulae in pairs, whereas scarcely any pairs exist. He examines the tidal, and other theories of the origin of moons and planets, and shows generally that although they have much to recommend them yet all fail in giving a thoroughly satisfactory explanation.

The main portion of this book, as its title suggests, is concerned with the geology of the Earth and its evolution as

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an abode of life, and it is a masterly summary of the theories, of the agencies at work, of the beginnings of life, of the varied procession of the animal kingdom with its background of geographical scenery and vegetable life.

Mr. Grew has an interesting chapter on age and climate, and discusses the possible effect of radio-activity on this problem. He says nothing of Croll's astronomic theory of "Climate and Time." Surely altered eccentricity to the extent of thirteen millions of miles must affect climate, and must affect ocean levels. It may not have so stupendous an effect as its originator suggests, but it must have an action that would have been worth discussing in so full a treatment of the subject as is given in this book. A long severe winter in one hemisphere during which most of the polar water must fall as snow, will assuredly be strikingly different from the other polar hemisphere, where during the short mild winter most of the condensed water will fall as rain, and hence flow off, and leave the earth surface ready to be warmed at once by the summer sun; whereas the summer sun in the other hemisphere must obviously be largely engaged in melting the ice that has accumulated in the long cold winter. There is but little doubt that Croll's theory is deserving of more attention than it has received of late years. This very able book, so largely devoted to contrasting and estimating the value of rival theories, and that so clearly shows the unsatisfactory nature of most of them, will doubtless help to a revaluation of theories that have been too hastily rejected, and help much towards a solution of many problems. No impression of this book is more evident than that the study of generalizations is the urgent need of the moment. The book is heartily recommended to every one of the readers of "KNOWLEDGE"; it is as interesting as a novel, and is especially characterized by the same aim as that of "KNOWLEDGE," namely the subject is plainly worded and exactly described.

A. W. B.

MINERALOGY.

Gem-Stones.—By G. F. HERBERT SMITH. 312 pages. 32 plates. 7¾-in. × 5-in.
(Methuen & Co. Price 6/- net.)

Besides forming an excellent work of reference and giving details as to the articles and manufacture of stones and methods of mining, Mr. Herbert Smith's book is of considerable interest to the general reader. A chapter is devoted to "Historical Diamonds," for instance, and remarks are made as to the powers of resistance which stones used in jewellery should have against the mechanical and chemical actions of everyday life. Gem-stones, we are told, should be at least as hard as the minute grains of sand in ordinary dust. This is a condition fulfilled by all the principal species with the exception of opal, turquoise, and one or two others. The beauty of the first-named does not depend upon the brilliancy of its polish, so that surface scratches are not of much importance. If there is the slightest degree of porosity the stone is likely to be affected chemically. It is risky to wet turquoises, even with water, lest the bluish-green colour be oxidised to the despised yellowish hue. There is some chance of opals, moon stones and star stones being damaged by the penetration of grease into their interior, and as the charm of pearls may easily be destroyed in the same way or by contamination with grease, ink, or similar matter, while they are also soft, their use in rings is much to be deprecated. The book contains a wealth of illustrations, and the plates in three colour give a very good idea of the tints and appearance of the stones shown.

NATURAL HISTORY.

The Arctic Prairies.—By ERNEST THOMPSON SETON. 415 pages. 54 illustrations. 9-in. × 6-in.
(Constable & Co. Price 12/6 net.)

The many admirers of Mr. E. Thompson Seton's work will welcome this account of a canoe-journey of two thousand miles which he made at his own expense and for his own pleasure, in search of the Caribou in the far North-West. The book consists of a graphic account of travel, of natural history observations, illustrated with thumb-nail sketches, finished drawings of animals and with photographs. In fact, almost everything that was new or interesting to Mr. Seton is represented, from the dry wallows in which the buffaloes get relief from flies, to the footprints of the black bear and musk-ox, primitive windlasses, birch bark pails, and the various plants that were noticed from time to time. Mr. Seton not only saw many and great herds of the deer which he went so far to find, but met with numerous things which he did not expect and which in his own inimitable style he brings before his readers.

Wimbledon Common.—By WALTER JOHNSON. 304 pages. 4 maps. 25 illustrations. 8¼-in. × 5½-in.
(T. Fisher Unwin. Price 5/- net.)

In these days it is being abundantly recognised that the study of history and geography should begin at home, and it is quite obvious that those who are attracted by their natural environment will turn first to what is nearest at hand. To those who are not aware of the interest which can be found even in a London suburb which is blessed by the possession of open spaces, this account of Wimbledon Common will come as a surprise; and we may confidently say that every person who claims to be intellectual, and who lives in the neighbourhood, should read the book, while it should serve as an example and an encouragement to dwellers in other neighbourhoods to collect material for similar and equally valuable compilations.

ORNITHOLOGY.

A Hand-List of British Birds with an account of the Distribution of each species in the British Isles and Abroad.—By ERNST HARTERT, F. C. R. JOURDAIN, N. F. TICEHURST and H. F. WITHERBY. xii. and 237 pages. 8¾-in. × 5¾-in.
(Witherby & Co. Price 7/6 net.)

This work is certain to prove most useful to ornithologists, supplying, as it does, in one volume of moderate size and in concise terms, a mass of detailed information only available hitherto in various separate publications. It may well rank as the British ornithologist's vade-mecum; for ourselves we have found that, in the short time it has been in our hands, it has already secured a place of preference as a source of reliable information, and that we are continually referring to it. The title indicates the ground covered, and in addition notes are given on the migration of some species. As regards distribution, this is given with considerable detail for each of the three countries of the United Kingdom separately, and frequently for smaller geographical divisions, and this arduous and laborious task has been accomplished with completeness and success. The distribution abroad is also briefly given. It is rather to be regretted, however, that, in aiming at conciseness of language, telegraphese English is used, sometimes to the extent of obscuring the meaning of the sentence. An admirable brevity would still have been preserved had the authors allowed themselves the conventional use of conjunctions and prepositions. The number of species on the British list steadily increases and the present work admits four hundred and sixty-nine, as compared with Howard Saunders' "List" (1907) which has four hundred and fifteen, excluding doubtful records. We think that a brief analysis and summary into groups, such as resident birds, summer visitants and otherwise would have been instructive as bringing out one of the striking characteristics of our avi-fauna.

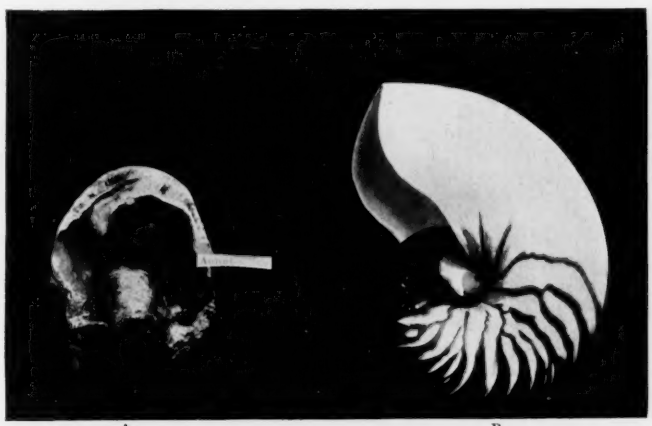
The distributional portion of the book is, we are sure, what the working ornithologist will most value, but it should be said that the authors seem to consider nomenclature to be of equal, if not greater, importance. They have certainly had the courage to place a heavy handicap on the acceptability of their work, by the sweeping and radical character of the changes made in the scientific names. Many of the bibliographical and critical notes elucidating this part of the work are of great interest, but the system which imposes such names as *Troglodytes troglodytes troglodytes* (L.) on the Wren (and there are many other similar names), has taken upon its shoulders a very heavy burden indeed,—even although it is based upon pure reason. Appearances are against it.

H. B. W.

THE PEARLY NAUTILUS: SOME HOMOLOGIES BETWEEN FOSSIL AND LIVING FORMS.

By A. R. HORWOOD.

It is well-known that the Pearly Nautilus* is the single living survivor (generically) of a once numerous and diverse group of Cephalopods which commenced with a prototype, possibly like *Tentaculites*, having a straight shell. Moreover, it has been established that the race evolved from a straight shell such as *Orthoceras* (see Figure 399), a type having a slightly-curved shell like *Cyrtoceras* (see Figure 400); and that in course of time this was again succeeded by a loosely-coiled form which had a spiral shell in which the whorls were not in contact, like *Gyroceras* (see Figure 401). Finally, there was a type in which the shell was closely-coiled, and in which later whorls overlapped the earlier ones, and of such a type was the early Nautilus (see Figure 402), whose descendants inhabit the Indian and Pacific Oceans to-day in pelagic depths. Such, briefly, is the course of phylogeny or race-history amongst the tetrabranchiate types of Cephalopods, and it is due to the researches of many palaeontologists that we now know that the life-history of a Cephalopod is a repetition of that of the earlier race-groups.



A B

From a photograph by A. Newton.

FIGURE 398.

A. Liassic *Nautilus striatus* J. de C. Sow., showing "black layer" and annular lobe.

B. Young Shell of living *Nautilus pompilius* L. showing "black layer" (lateral view).

No one contributed more towards the establishment of this great principle than the late Professor Alpheus Hyatt. He showed, amongst other things, that in the early stages of Nautilus it went through a *Cyrtoceras*-like stage (see Figure 400), when the shell was in shape like a ram's horn, uncoiled; and this stage was only the successor to a previous straight stage in which the protoconch was straight, and in line with the first chamber. But unfortunately this protoconch is only revealed in living as well as fossil forms by the scar left by its junction with the first or initial chamber; for the protoconch itself, possibly membranous, has disappeared.

Many other facts have been elicited by a study of the fossil Cephalopoda which all tend to corroborate this broad principle of the recapitulation of race characters by the individual, which support in a very convincing and empirical manner the still wider and more general principle of progressive evolution. That there has been retrogression, too, this very group, the Cephalopoda, bears out in a remarkable degree, not only in the senile stages acquired by the individuals in both two- and four-gilled groups, but also in the race-history, where the former became exceedingly abnormal, retrogressive, and finally extinct, in cretaceous times.

With this in view it is not remarkable that both fossil and living forms are found to exhibit in an extraordinary manner very perfect homologies between the organs adapted for any particular function in past and present times, and in the effects of their action. And no group of Cephalopods exhibits this characteristic more markedly than the Nautiloids; for in a considerable number of cases the means by which the animal was attached to the shell by shell-muscles in the last or living-chamber, and the marks left upon the shell-wall by the muscular impressions, was almost exactly identical in past times (as in the Jurassic period) as to-day.

And when we consider the extremely specialized nature of the habitat of the Pearly Nautilus—more or less deep-sea conditions, where little or no variation in depth, light, warmth, currents, or composition of the water could be effected—it is intelligible that the mode of attachment and similar characteristics of this interesting species should remain practically the same throughout a vast lapse of time. For it is

* There are four living species.

XUM

quite fully established that the effect of external conditions, once rather underestimated, has a distinct influence upon the course and nature of evolution. That the Ammonites had similar modes of attachment of the animal to the shell is abundantly illustrated by the testimony of numerous specimens exhibiting the same characteristic.

The composition and structure of the shell in Nautilus and its early ancestors has also remained remarkably uniform. Thus, in the fossil forms we find the shell consisting of two layers, an internal nacreous iridescent layer formed internally, and an external thicker layer formed by the mantle edges, whilst in addition to these, which are superposed in an imbricate manner like tiles, there was a "black layer," which was formed externally by the hood, representing the animal matter which was secreted by that organ. The same "black layer" is found within a double wall on either side of the inner and outer layers in the earlier parts of the shell before the last septum, as seen in the diagram. It occurs outside only in the volute part of the shell because there the wall is not duplicated as it is where the walls of newer and older chambers were in contact. The presence of this "black layer" between the two other layers placed on either side is demonstrated by the decalcification of a portion in acid, when there remains a certain quantity of organic matter representing the former "black layer." And the formation of shells is now held to be due to excretion and formed by the mantle or arms of the animal, by the building up of carbonate of lime upon a membrane of organic matter of a chitinous nature. This is the condition of the "black layer." The periostracum of many bivalves and univalves is formed by the mantle, and is the first-formed part of the shell, the calcareous part and coloured layer being deposited next; but, unlike the "black layer," the periostracum is only a protection, and a make-shift as it were, and not a permanent part of the shell, not being absorbed into the interior in a coiled species but eventually disappearing. The operculum of some species is deposited by the foot, and is not homologous with the last or the "black layer."

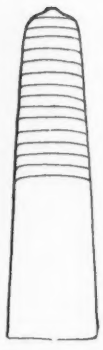


FIGURE 399.
Straight-shelled Cephalopod, *Orthoceras* type (reduced).

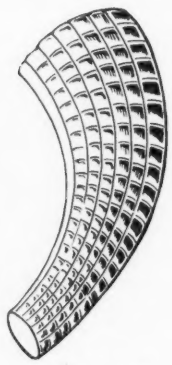


FIGURE 400.
Curved-shelled Cephalopod, *Cyrtoceras* type (reduced).

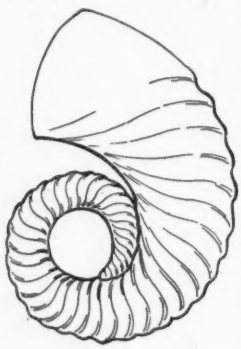


FIGURE 401.
Loosely-coiled Cephalopod, *Gyroceras* type (reduced).

It is a point of some interest that the "black layer" which forms the inner dividing layer of two contiguous, but opposite, shell-walls, should be preserved in fossil forms of Nautilus in as perfect a manner as that which is seen so clearly in living examples of the Pearly Nautilus.

This is well-illustrated in the accompanying photograph of the Liassic *Nautilus striatus* Sow. (see Figure 398 A), and a young example of the living Pearly Nautilus. In young forms of the latter the deposit is a shiny black opaque layer which is remarkably smooth and jet-like. But in older examples there are numerous plicae or folds coinciding with the gradual encroachment of the hood upon the coloured shell surface, which is the ventral surface continued, and lies next to the dorsal lobe of the hood which would be against the dorsal side of the shell if it were continued beyond the last septum, which is not the case. These plicae are reproduced in the fossil form. Upon the surface also may be observed both in the recent Nautilus and in this Liassic species, numerous excrescences, which represent the papillae on the hood. Such a remarkable resemblance between species so remote in relationship is truly extraordinary.

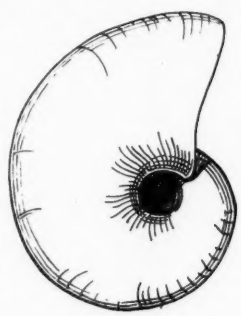


FIGURE 402.
Closely-coiled Cephalopod, *Nautilus* type (reduced).

FIGURE 403.
Section through an early stage *Nautilus* to show central black layer (enlarged).

But in these two specimens again we have a further interesting feature, for in the Liassic species below the central siphuncular impression is a similar, but depressed, ring-like marking, which represents the annular or median dorsal lobe. It is not often to be detected in the last septum of *Nautilus pompilius* (see Figure 398 B), but is represented in earlier septa, and in some young forms by the little pit-like hollow here seen in *Nautilus striatus*.

The occurrence of two similar features in the Liassic and present-day Nautilus is interesting, as it indicates the presence in both of an annular muscle. No figure of the "black layer" in a fossil species has hitherto appeared.

TO FIND THE DAY OF THE WEEK.

By JAMES ASHER.

FOUR new methods of finding the day of the week in any year, when the corresponding date in some other year is given, have been recently devised by the writer. These will presently be described.

Before these methods can be used it is desirable to know how to tell whether a year is leap year, also to tell how many leap days are between a date in a given year and the corresponding date in any other given year. The writer has also devised new methods for these.

A year is leap year if the number expressed by the last two figures is a multiple of 4. Thus 1908 was leap year for 08 is a multiple of 4. The year 1927 will not be leap year, for 27 is not a multiple of 4. On dividing 27 by 4, the remainder shows that 1927 will be the third after leap year.

Since 1752, centennial years not divisible by 400 are not leap years. Thus 1800 and 1900 were not, but 2,000 and 2,400 will be leap years. The centennial years before 1752 were all leap years from the time of Julius Caesar.

It was decreed that, in England and its colonies, the day after September 2nd, 1752, should be called the fourteenth. It was also decreed that, thereafter, of the centennial years, only those which were multiples of 400 should be leap years. Further, it was ordered that the year should begin on January 1st, instead of March 25th.

To find the number of leap days between a given date in one year and the corresponding date in another:—

Find the number of years from first February 29th, after the date in first year to the first February 29th, after the date in the last year, and divide by 4. If any centennial years, after 1752, not multiples of 400, intervene between the first February 29th, after the date in the first year and the first February 29th after the date in the last year, subtract one for each, after making the simple calculation.

But, when the first and the last year are both leap years, it is better to subtract the first from the last, and divide by 4. If any centennial years since 1752, not multiples of 400, intervene between the first and the last year, subtract one for each, after performing the division.

If the day of the month in the first year of the period is on or before September 2nd, 1752, and the last year is after 1752, do not use the same day of the month in the last year, but use a date 11 days later, in making calculations according to the methods to be presently described.

First problem, first method:—

Magna Charta was signed by King John and the barons, June 15th, 1215.

Find the day of the week, knowing that June 26th, 1912, was Wednesday.

Solution:—

The period is 697 years. From February 29th, 1216, to February 29th, 1916, are 700 years. The fourth of 700 is 175. We subtract 2 from this because 1800 and 1900 were not leap years. Thus we find that there were 173 leap days.

In the 697 tropical years from June 15th, 1215, to June 26th, 1912, there are

$697 \times 365 + 173 = 254{,}578$ days, or 36,368 weeks and 2 days.

When the number of weeks is a whole number, in other words when no days remain, the day of the week required is, evidently, the same as the given day of the week. In solving the problem we have found 2 for remainder. This shows that the required day of the week is two days farther back than our given day of the week. Now the given day is Wednesday. Count backward 2 days to Monday, the answer.

In solving problems by any of the methods described in this article, if the given day of the week is in the first year, in using the remainder, count forward.

Second problem, by a second method:—

Christopher Columbus discovered America, October 12th, 1492. Find the day of the week, knowing that October 23rd, 1912, will be Wednesday.

Solution:—

The period is 420 years. The first and last year are leap years. The fourth of 420 is 105. We subtract 2 from this, because 1800 and 1900 were not leap years. We thus find that there were 103 leap days in the period.

In the 420 years there were $420 \times 365 + 103$ days.

It will be seen that 420 is a multiple of 7, consequently 420×365 days is a whole number of weeks, and we need do nothing with 420 and 365. Divide 103 by 7 and find 5, the remainder. Count backward 5 days to Friday, the answer.

This method can be used only when the number of years is a multiple of 7.

Third problem, by a third method:—

Queen Victoria was married February 10th, 1840. Find the day of the week, knowing that February 10th, 1891, was Tuesday.

Solution:—

The period is 51 years. The first February 29th after February 10th, 1840, was February 29th, 1840. The first February 29th after February 10th, 1891, was February 29th, 1892. From February 29th, 1840, to February 29th, 1892, were 52 years. The number of leap days is found by dividing 52 by 4. We thus find that there were 13 leap days between February 10th, 1840, and February 10th, 1891.

In the 51 years there were $51 \times 364 + 51 + 13$ days.

The number 7 is a factor of 364, therefore 51×364 days is a whole number of weeks, and nothing need be done with it. Divide the sum of 51 and 13 by 7, and find that 1 is the remainder. Count backward one day from Tuesday to Monday, the answer.

Our proceeding may be set down as a rule thus: Call the number of years in the period, days; to this add the number of leap days in the period, then divide by 7. Count backward from the given day of the week as many days as there are in the remainder. But if the first date is on the given day of the week, count forward.

Fourth problem, by the third method:

Standard time was adopted, in the greater part of North America, November 18th, 1883. Find the day of the week, knowing that November 18th, 1912, will be Monday.

Solution:

The period is 29 years. The number of years from February 29th, 1884 to February 29th, 1916, is 32. The fourth part is 8. Subtract 1 because 1900 was not leap year. We thus find that there were 7 leap days.

We may omit some of the figures that were shown in solving a problem by the third method. We add together a number of days equal to the number of years in our period, and the number of leap days, then divide by 7. Now the sum of 29 and 7, divided by 7, gives 1 for remainder. Count backward 1, from Monday to Sunday, the answer.

Fifth problem, by a fourth method:—

Charles Robert Darwin and Abraham Lincoln were born on the same day February, 12th, 1809. Find on what day of the week was the hundreth anniversary of their births, knowing that February 12th, 1912, was Monday.

Solution:—

The days of the week seem to step ahead one day each year as you go forward, and to step backward one day if you go backward in reading. In leap year, after leap day, the day of the week will be found two days ahead of the day on the corresponding date in the previous year.

In our problem the period is 3 years. There are no leap days, because our period ends before leap day, or February

29th, 1912. We count backward 3 days from Monday to Friday, answer.

This method can be readily used when the period is short.

Sixth problem, by third method :—

The next transit of Venus will be on June 8th, 2004. Find the day of the week, knowing that June 8th, 1912, was Saturday.

Solution :—

The period is 92 years. Both first and last are leap years. The number of leap days is one fourth of 92 or 23. The sum of 92 and 23 divided by 7 gives a remainder 3. Count *forward* 3 days from Saturday to Tuesday, the answer.

When it is required to know on what day of the week February 29th, either was or will be, find the day of the week for February 28th, of the same year, by one of the methods herein described, then count forward one day.

Seventh problem.

Find on what day of the week February 29th, 3992, will be knowing that February 28th, 1912, was Wednesday.

Solution :—

The period is 2080 years. Both first and last are leap years. The fourth of 2080 is 520. The years 21, 22, 23, 25, 26, 27, 29, 30, 31, 33, 34, 35, 37, 38 and 3900 will not be leap years. There are 15 of these. Substract 15 from 520 and find that there will be 505 leap days. The sum of 2080 and 505 divided by 7 gives 2 for remainder. Count forward 2 days from Wednesday, and find that February 28th, 3992, will be Friday. Of course, February 29th, 3992, will be Saturday, the answer.

The third method is the best for general use.

Should the reader prefer, he may find the number of leap days between the two given dates by counting. For example, in the fourth problem, he can see that between November 18th, 1883, and November 18th, 1912, were the following leap days—February 29th, 1884, 1888, 1892, 1896, 1904, 1908 and 1912. There are 7 of these, as we have already found.

NOTICES.

THE DUNDEE MEETING OF THE BRITISH ASSOCIATION.—The meeting of the British Association which opens under the general presidency of Professor Schäfer at Dundee on September 4th, bids fair to be an excellent and an enjoyable one. The city, as we can speak from pleasurable experience, knows how to entertain its visitors right royally, and one feature of the meeting will be the large number of foreign guests. Judging, too, from the presidential addresses to the Association as a whole, and to the various sections, which we are privileged to read, but whose nature we are not permitted to reveal until they have been delivered, members old and new who go to Dundee will not regret having made the journey. In this connection we have pleasure in reproducing for the benefit of our readers a time table of the trains from Euston, which the London and North Western Railway has kindly forwarded to us.

		Week-days.			
		L T	L D	S	S sx
		a.m.	p.m.	p.m.	p.m.
LONDON (Euston) ...	dep.	10.5	2.0	8.0	11.45
		A			Ax
		p.m.	a.m.	a.m.	a.m.
DUNDEE (West Station)	arr.	8.50	1.15	6.45	9.52

		Sundays.		
		S		
		p.m.	p.m.	p.m.
LONDON (Euston) ...	dep.	8.0	8.50	11.45
		a.m.	a.m.	a.m.
DUNDEE (West Station)	arr.	6.45	9.37	9.52

NOTES :

L T—Luncheon and Tea Cars.
L D—Luncheon and Dining Cars.
S—Sleeping Cars attached.
S sx—Sleeping Cars attached, except Saturday Nights.
A—Through Carriages to Dundee.
Ax—Through Carriages to Dundee, except Saturday Nights.

Charge for sleeping berth 10s. in addition to first class fare.

HOUSE FLIES.—Of recent years the harm which house flies may do in the carrying of infection has been emphasised. Some very careful experiments, which are described by Dr. Graham-Smith in the current number of *Bedrock*, give a clear idea as to how long after contamination the germs of disease flies may continue to be dangerous. The typhoid bacillus may remain alive in the intestines of the flies for at least six days and flies can infect materials over which they walk for at least two days. Bacilli which produce the symptoms of meat poisoning behave in the same way. Tubercle bacilli can be found in the intestines of flies ten days or more after infection. In the case of germs which produce spores that can only be killed with great difficulty, these may remain on the dead fly for months or even years. It was also shown that flies which feed on milk, or which tumble into it, are capable of infecting it, and although under ordinary conditions in this country the adult fly seldom has the opportunity of feeding on materials infected with disease-producing bacteria, yet the maggots are often probably infected. Further researches are being made into the question whether the flies which spring from these would also be infected, and we await the results with much interest.

CLASSES IN PHOTOGRAPHY.—We have pleasure in announcing that Mr. Edgar Senior's classes in Photography for the autumn session will open at the following Polytechnics on the dates specified: Battersea, Tuesday, October 1st; South Western, Monday, September 23rd; and Woolwich, Wednesday, September 25th, 1912.

THE OPTICAL CONVENTION, 1912.—With further reference to new apparatus exhibited at the Optical Convention ("KNOWLEDGE," August, 1912, page 291) we may refer to that shown by Messrs. Newton & Co. Special mention should be made of Cheshire's Optical Apparatus, never before exhibited in the complete form in which it was shown at work during the Convention. It consists of an optical bench which can be mounted in the form of a Projection Spectroscope, Polariscope or any similar apparatus. The Colour Projection portion is probably the best method of showing the composition of white light at present devised, and consists of recomposing the spectrum on the screen by means of a convex lens. In the spectrum itself is then placed a number of wedge prisms cut slant-wise, which reflect portions of the recomposed beam upwards and outwards so as to give a number of overlapping colour discs. These discs change their tints as the wedge prisms are moved along the spectrum, but they are always complementary, and the overlapping portion in the centre is always white.

Another development of the same apparatus is the Model Eye, also arranged for projection on the screen, the picture of the retina itself being projected and the various defects due to presbyopia, myopia and astigmatism demonstrated.

Another instrument shown was a cheap three and a half inch astronomical telescope, of great optical perfection, on a simple yet strong altazimuth stand. In addition to these there was a full range of the firm's well known optical apparatus.

WHAT DETERMINES SEX.—To *Scientia* for May, Professor Arthur Thomson contributes a critical essay entitled, "What determines sex." He discusses five different theories, and concludes by giving his own view that the difference between an ovum-producer and a sperm-producer is fundamentally a difference in the balance of chemical changes, that is, in the ratio of anabolic and katabolic processes which may, of course, have its structural expression in the relation of nucleo-plasm and cytoplasm. In fact, he adheres to the thesis of his book, "The Evolution of Sex," that the sex-difference is one expression of a fundamental alternative in variation to be seen throughout the world of life.